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FARMERS' BULLETINS
Nos. 1301-1325

WITH CONTENTS

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No 1301

The COMMON WHITE WHEATS

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THE COMMON WHITE WHEATS include those varieties of common wheat which have white kernels. The class includes both winter and spring varieties having either soft or hard kernels. The States of Washington, California, Oregon, Idaho, and New York lead in their production. Over 3,000,000 acres are grown annually in the United States, comprising about 5 per cent of the total wheat acreage.

Most of the common white wheats are soft and are used in the making of pastry flour and breakfast foods or are blended with hard wheats for bread-making flours.

Of this class of wheat 52 varieties are grown commercially in the United States; of these 35 are spring wheats and 17 are winter wheats.

Pacific Bluestem is the variety most widely grown. It is the most productive spring wheat in eastern Washington and northern Idaho where the rainfall exceeds 15 inches and is well adapted to the Sacramento Valley of California.

Baart is the most productive spring wheat in Washington where the rainfall is less than 15 inches. It is well adapted to central and eastern Oregon and to the drier sections of California and is very suitable for bread making.

Hard Federation has outyielded Baart and Pacific Bluestem on the dry lands in eastern Oregon and has proved to be well adapted in California. It has hard kernels and is of excellent quality for bread making.

Federation, in recent experiments, has outyielded all other varieties on the irrigated lands of southern Idaho and southeastern Oregon. It exceeds Dicklow, the variety most widely grown there, in both yield and quality.

Goldcoin is the winter variety of white wheat most widely grown. Except in certain localities it should be replaced by more productive varieties of better quality.

White Winter is the variety giving the highest yields in the Willamette Valley of Oregon.

Dawson is the white winter variety most productive in most of Michigan, New York, and Pennsylvania. Honor, a selection from Dawson, has outyielded the latter in New York.

Washington, D. C.   December, 1922

THE COMMON WHITE WHEATS.[1]

By J. ALLEN CLARK, *Agronomist in Charge*, JOHN H. MARTIN, *Agronomist, Western Wheat Investigations*, and C. E. LEIGHTY, *Agronomist in Charge, Eastern Wheat Investigations, Office of Cereal Investigations, Bureau of Plant Industry.*

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COMMON WHITE WHEATS DEFINED.

The common white wheats include those varieties of common wheat having white kernels. Under the Official Grain Standards of the United States wheat is graded into five classes, one of which is designated as "Class V, White Wheat." This class includes the white-kerneled varieties of both common and club wheats, but only the common wheats are considered in this bulletin. Although most of the durum varieties also have white kernels, they are not here listed.

The kernels are described as white because they lack the coloring matter or pigment in the seed coat, or bran, which red wheats possess. The kernels are not really white, but rather a pale yellow. The kernels may be hard and translucent (amber) or soft and opaque. Both winter and spring varieties are grown.

Over 3,000,000 acres, or about 5.4 per cent of the wheat acreage of the United States, are devoted annually to the production of this class of wheat, of which 52 varieties are commercially grown.

WHERE GROWN.

Common white wheats are grown principally in the Pacific coast area. The States leading in their production are Washington, California, Oregon, and Idaho. A considerable acreage also is grown in New York, Michigan, Colorado, and Utah. The section of heaviest production is in eastern Washington. Their distribution in the United States in 1919 is shown in Figure 1. It was estimated that 3,947,300 acres of common white wheat (including Sonora) were grown in that year. While not as extensively grown as most other classes, it is the leading class of wheat grown in Arizona, California, Idaho, Nevada, New York, Oregon, Utah, and Washington.

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[1] The information given in this bulletin is based upon (1) varietal experiments conducted by the Office of Cereal Investigations of the Bureau of Plant Industry, United States Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) a survey of the wheat varieties of the United States, in cooperation with the then Bureau of Crop Estimates, based on 19,000 returns from 70,000 questionnaires sent to crop correspondents; (4) several years of personal observation by the writers of the wheat fields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Milling Investigations Section of the Bureau of Agricultural Economics in cooperation with the Office of Cereal Investigations.

AREAS TO WHICH ADAPTED.

The common white wheats are adapted in general to the districts of heavy production shown on the map in Figure 1. In Michigan, New York, Ohio, and other Eastern States, only winter varieties are grown. In Arizona, California, Colorado, and Nevada, practically all of the common white wheats are of spring varieties, although usually fall sown except in Colorado. In the other Western States both winter and spring varieties are grown.

Common white wheats give the highest comparative yields in most of Arizona, California, Nevada, western Oregon, and southern Idaho. In eastern Washington, eastern Oregon, and northern Idaho they usually are outyielded by winter varieties of other classes of wheat, including club and hard red winter, and occasionally by varieties of soft red winter and hard red spring wheats. In these sections certain common white varieties usually are the most productive of the spring wheats. White wheats are of considerable importance in many of the irrigated sections of Colorado and Utah.

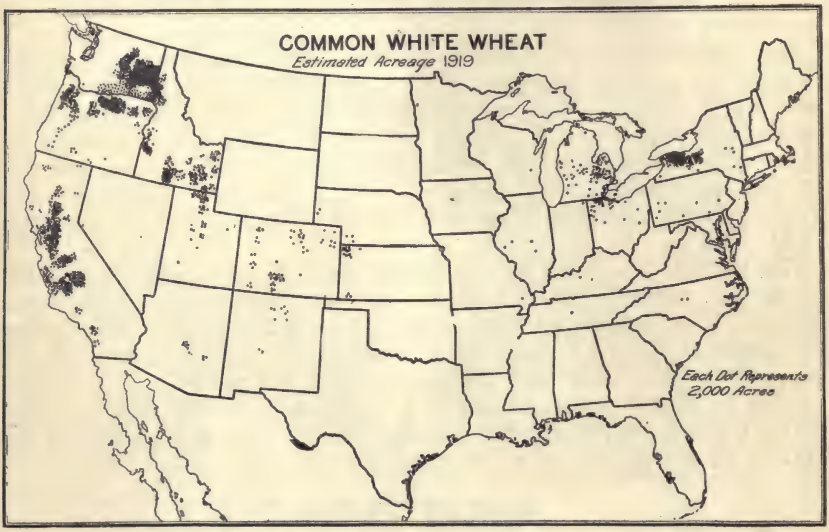

FIG. 1.—Outline map of the United States, showing where common white wheat was grown in 1919. Estimated area, 3,947,300 acres.

In New York, Ohio, and parts of Michigan, winter varieties of common white wheat usually outyield all other varieties. The soft red winter wheats are, however, more important in these States, except New York, because there is usually a larger demand and better price for red wheat in this area. In the eastern half of the United States, outside of the area comprising the three States named and a portion of Pennsylvania, the red wheats almost universally outyield the common white varieties.

In general, the common white wheats are inferior to the hard red spring and hard red winter wheats for bread making. A few common white varieties, however, have a high bread-making value and are used for grinding into bread-making flours without blending. The common white wheats of the West are grown principally in areas (both irrigated and nonirrigated) where soil and climatic conditions do not favor the production of wheat of high quality. Much of the common white wheat produced is soft, starchy, and of a low gluten content.

The common white wheats, even when soft and starchy, are well suited to the manufacture of pastry flours, crackers, and breakfast foods. Large quantities of common white wheat are used for the above purposes in both the eastern and the western parts of the United States. Except in small local mills, the wheat or flour of soft common white varieties is blended with that of good hard white or hard red spring or hard red winter varieties for manufacturing bread-making flours. With its usual lower price, this class must outyield other classes of wheat sufficiently to offset the difference in price. The soft white wheats are extensively exported, and when this demand is good the price of white wheat is sometimes greater than that of the hard red wheats. In certain localities there also is a local demand for white wheat for special purposes, such as the making of whole-wheat products, which results in good prices for it. In the sections where common white wheats are best adapted they usually are more profitable than other classes.

VARIETIES.

Some 52 distinct varieties of common white wheat are grown commercially in the United States. These wheats are known by about 170 names. Of the distinct varieties, 35 are spring wheats and 17 are winter wheats. The varieties also differ widely in yield, quality, earliness, and adaptation, as well as in general appearance and behavior. For convenience in discussion the varieties of common white wheat are here grouped into 12 sections on the basis of the most easily observed characters of the head, chaff, and plant.

DISTINGUISHING CHARACTERS AND VARIETIES.

Section 1.—Heads beardless; chaff glabrous (not velvety), white or yellow; winter wheats:

White Winter. Eaton. Martin. Prohibition. Greeson. White Wonder. Winter Bluestem.

Section 2.—Heads beardless; chaff glabrous (not velvety), white or yellow; spring wheats:

Pacific Bluestem. Mexican Bluestem. Bunyip. Dart. White Federation. Bobs. Defiance. Regenerated Defiance. Early Defiance. Colorado No. 50. Lynn. Touse. New Zealand. Gypsum. Surprise. Dicklow. Quality. White Fife. Rink. Pilcraw.

Section 3.—Heads beardless; chaff glabrous (not velvety), brown or red; winter wheats:

Goldcoin. Dawson. Honor. Arcadian. Windsor. Kofod.

Section 4.—Heads beardless; chaff glabrous (not velvety), brown or red; spring wheats:

Federation. Hard Federation. John Brown. Allen. Foisy.

Section 5.—Heads beardless; chaff velvety, white; winter wheat:

Silvercoin.

Section 6.—Heads beardless; chaff velvety, white; spring wheats:

Indian. Jumbuck.

Section 7.—Heads beardless; chaff velvety, brown or red; spring wheats:

Sonora. Galgalos.

Section 8.—Heads bearded; chaff glabrous (not velvety), white; winter wheat:

Democrat.

Section 9.—Heads bearded; chaff glabrous (not velvety), white or yellow; spring wheats:

Baart. Propo. Palisade. Talimka.

Section 10.—Heads bearded; chaff glabrous (not velvety), brown; winter wheat:

Genesee Giant.

Section 11.—Heads bearded; chaff glabrous (not velvety), brown; spring wheats:

Sevier. Canadian Red.

Section 12.—Heads bearded; chaff velvety, white; winter wheat:

Read.

Section 1.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW; WINTER WHEATS.

Section 1 includes seven winter varieties having beardless heads, glabrous white or yellow chaff, and soft white kernels. The kernels vary in size from small to large. The heads of some of the varieties are long and open, while others are shorter, more compact, and somewhat clubbed at the tip. The varieties comprising this section can be successfully grown only from fall sowing.

WHITE WINTER.

The White Winter variety (known also as Bishop's Pride, Oregon White, and Wold's White Winter) has beardless heads, glabrous white chaff, and soft white kernels. The heads are erect, of medium length, compact, and square tipped (Fig. 2, *B*). The kernels are short and rounded. It is a late-maturing winter wheat and will not produce a crop if sown in the spring. It is not very hardy as a winter wheat.

White Winter is one of the oldest wheats grown in western Oregon, where it was the principal variety grown as early as 1855. It probably was introduced into that section from England. It is now grown in the humid sections of western Oregon and in one county in northern California. More than 50,000 acres of this variety were grown in 1919.

White Winter is one of the highest yielding varieties in the Willamette Valley of Oregon. Because of its late maturity it is adapted only to humid sections having cool summer weather. It can be grown with success in the United States only in the humid areas of the Pacific Northwest. Being soft and starchy, White Winter is not suitable for the manufacture of bread-making flour of high quality.

EATON.

The Eaton variety is nearly identical with White Winter, but differs from it in having a slightly clubbed head (Fig. 3, *A*). The origin of Eaton is not known, but it probably is an old English variety, like White Winter. Eaton has been known in this country at least since 1894. It is now grown as a winter wheat in northwestern Oregon and in western Idaho, but not in large quantities. Slightly fewer than 10,000 acres were reported grown in 1919.

Eaton is about equal to White Winter in yield and quality and is adapted to practically the same conditions.

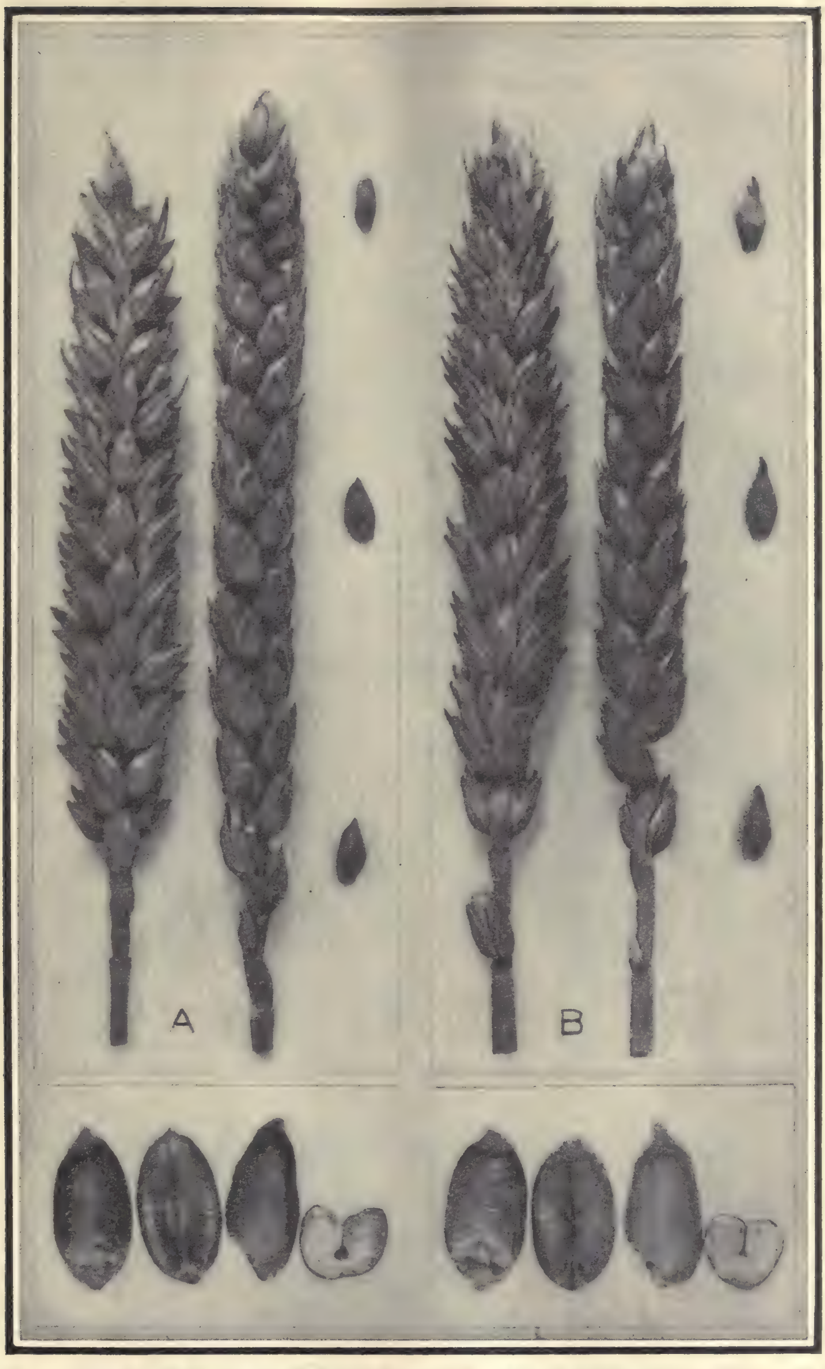

FIG. 2.—Heads, chaff, and kernels of Prohibition (*A*) and White Winter (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

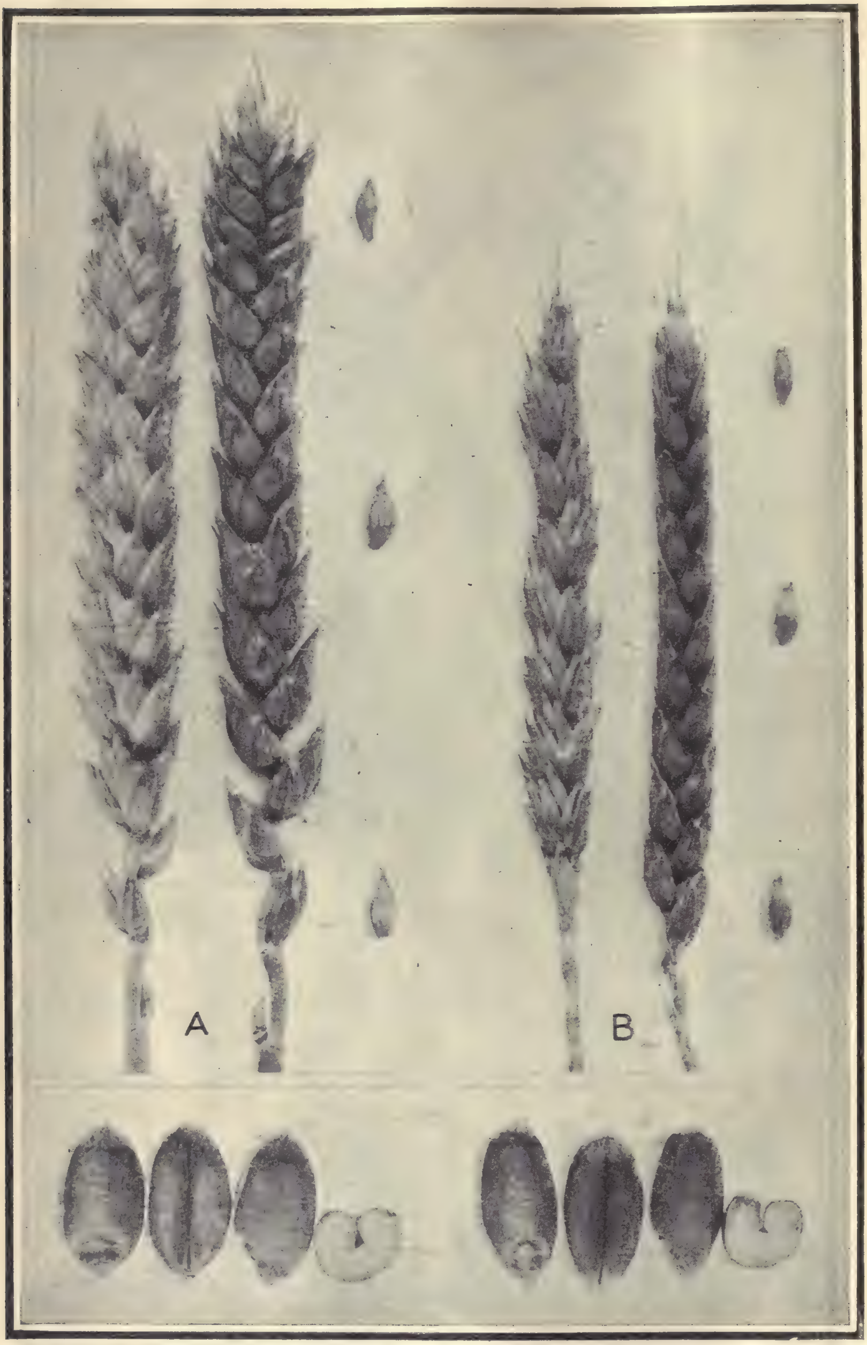

FIG. 3.—Heads, chaff, and kernels of Eaton (*A*) and Colorado No. 50 (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

MARTIN.

The Martin (Martin Amber) variety (known also as Amber, Armstrong, Landreth, Satisfaction, Silver Chaff, and White Amber) is distinct in having very long, slender, loose heads which are quite nodding. The plants are tall and midlate in ripening. The kernels are soft and midsized. A pure-line strain of this variety, not yet commercially grown, is very resistant to bunt or stinking smut, but the bulk variety, grown on farms, is not noticeably resistant to this disease.

Martin originated from a plant found in a field of Clawson in Seneca County, N. Y., about 1875. It was later distributed by seedsmen under the names Armstrong, Landreth, and Martin Amber.

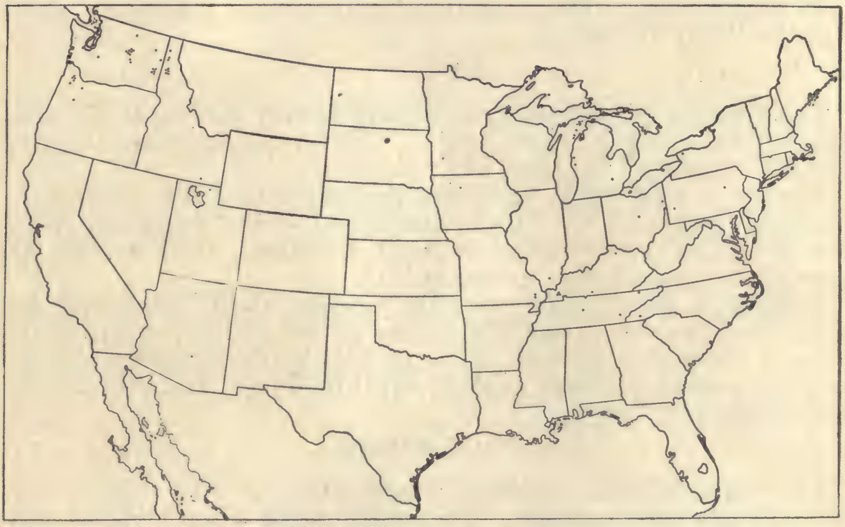

FIG. 4.—Outline map of the United States, showing the distribution of Martin wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 37,800 acres.

Although quite widely distributed both in the eastern and the western parts of the United States, Martin is not an important variety in any section, and less than 40,000 acres are grown in the United States. It is most important in Washington and Idaho. In the East it is most important in Kentucky, Michigan, and Missouri. The distribution is shown on the map in Figure 4.

Martin is not especially productive in any locality and is outyielded by one or more varieties in all sections where it is grown, both in the eastern and the western parts of the United States. The growing of this variety could be discontinued with profit.

It is a soft wheat and not of particularly high milling and baking quality. It probably is superior in quality, however, to several of the common white wheats.

PROHIBITION.

The Prohibition variety (known also as Prohi) is somewhat shorter and earlier than White Winter, and the heads are slightly longer and less erect (Fig. 2, *A*). The kernels of Prohibition are rather small, soft, and distinctly "humped;" that is, with a raised portion on the back of the kernel.

Prohibition was named and distributed by B. H. Irvine, of Scio, Oreg., about 1885. The seed of this variety had been obtained from the Commissioner of Agriculture at Washington under another name. The wheat was distributed in the vicinity of Scio, in Linn and Marion Counties, Oreg., where it is now grown on the red hill lands. About 25,000 acres of this variety were reported grown in 1919.

Prohibition apparently is well adapted to a limited area in the Willamette Valley of Oregon. It has scarcely been grown or tested outside of this locality, but owing to its lateness it probably is adapted only to cool humid sections.

In milling and baking qualities Prohibition is apparently about equal to White Winter.

GREESON.

The Greeson (or Greensboro) variety is very similar to Prohibition but has slightly longer heads. The kernels are more tapering and not "humped" like those of Prohibition.

Greeson is reported to have been originated by a Mr. Greeson, of Guilford County, N. C. It was distributed several years ago and is now grown in three counties in North Carolina. Only about 5,000 acres of this variety were grown in 1919.

Nothing is known concerning its yielding ability in comparison with other varieties except that it has become rather popular in the locality where it originated. Judging only by the appearance of the kernels, Greeson probably is about equal to White Winter in milling and baking qualities.

WHITE WONDER.

The White Wonder variety is nearly identical with Greeson, but the heads are more nodding. The origin of this wheat is not known. White Wonder is known to be grown in Lewis County, Va., and Oneida County, N. Y., but it is not an important variety in either locality. Nothing is known concerning the yield or quality of this variety in comparison with others.

WINTER BLUESTEM.

Winter Bluestem has square or slightly tapering compact heads. The heads have a shape similar to those of Pacific Bluestem. The kernels of Winter Bluestem are rather large and soft to semihard. It is grown only from fall sowing.

Winter Bluestem originated from a cross between Turkey (a hard red winter wheat) and Pacific Bluestem (a common white wheat) made at the Washington Agricultural Experiment Station, Pullman, Wash. It was first distributed from that station in 1912. The variety is now grown to a very limited extent in eastern Washington. It gives comparatively low yields. Winter Bluestem has rather semihard kernels and is of better milling and baking quality than the varieties thus far described.

Section 2.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW; SPRING WHEATS.

The varieties grouped under section 2 are spring wheats having beardless heads; glabrous white chaff; and soft, semihard, or hard white kernels. The heads of most of these varieties are slender and pointed, but a few have compact, square, or club-shaped heads. Although these varieties are true spring wheats, several of them are grown also from fall sowing in areas having mild winters.

PACIFIC BLUESTEM.

The Pacific Bluestem variety (the Bluestem wheat of the Pacific Coast States) also is known under the names Australian, Chile, Palouse Bluestem, White Australian, White Bluestem, White Chile, and White Elliott. This variety has beardless heads with yellowish white to light brownish chaff and soft to semihard white kernels. The heads are erect and nearly square, although they taper slightly at the tip (Fig. 5, *A*). The chaff is stiff and wide and not easily broken off. The kernels are of medium size and rather soft, but harder than those of some of the common white varieties. Pacific Bluestem is a true spring wheat, but is grown as a winter wheat in the mild climate of California and Arizona and occasionally in Oregon.

Pacific Bluestem is a very old variety of wheat. It formerly was called White Lammas and was the leading variety of wheat in Australia during the early years of wheat production in that country. The variety was introduced from Australia into California during the early fifties. In California this wheat is generally known as White Australian, but in the Pacific Northwest it is called Bluestem. It was introduced into the latter section in 1882 and was first grown in the Walla Walla Valley of Washington. Pacific Bluestem has been for many years the most widely grown variety of common white wheat and is still the leading spring wheat in the Pacific Northwest.

This variety is grown in all States west of the Rocky Mountains. It is of most importance in Washington, California, Idaho, and Oregon. It was estimated that more than 1,350,000 acres of it were grown in the United States in 1919 (Fig. 6).

Pacific Bluestem is the principal variety of wheat grown in the Sacramento Valley of California. There it usually is sown during the fall or winter, and by many growers it is considered a winter wheat. Until recently no variety of wheat has been able to compete with Pacific Bluestem (White Australian) in that section. Since 1918, however, the use of Baart, Bunyip, and a few other varieties has increased rapidly, but none has yet exceeded Pacific Bluestem in the acreage grown. In the San Joaquin Valley Baart usually outyields it. On the irrigated lands of southern California and Arizona it usually is outyielded by Baart, Defiance, and Sonora.

In the Palouse district of eastern Washington and Idaho Pacific Bluestem is the leading variety of spring wheat. It usually is outyielded by winter varieties in this section. In eastern Washington, eastern Oregon, and northern Idaho, where the annual rainfall ex-

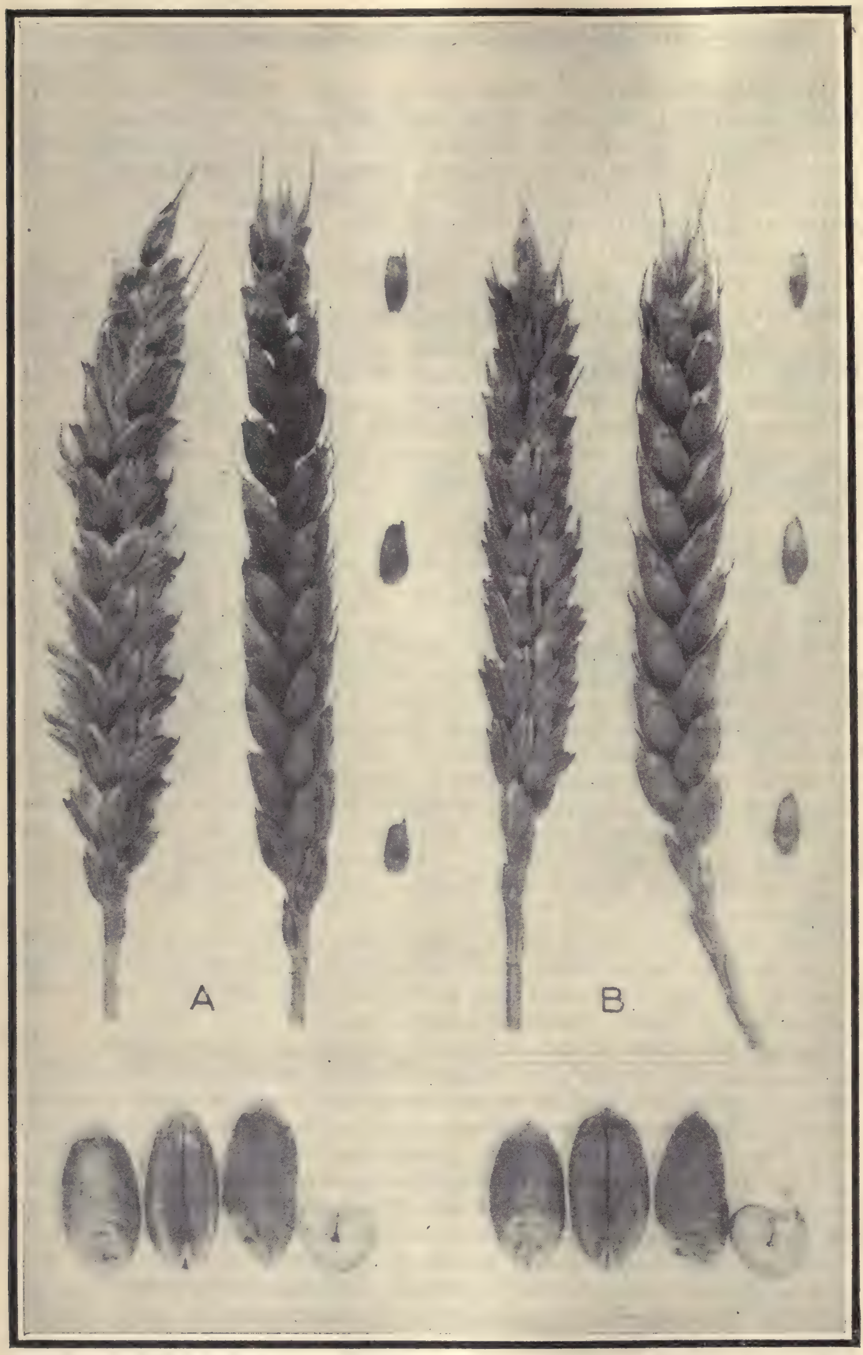

FIG. 5.—Heads, chaff, and kernels of Pacific Bluestem (*A*) and Gypsum (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

ceeds 15 inches, Pacific Bluestem is best adapted and is the principal spring wheat grown. Later-maturing varieties of club wheat frequently outyield Pacific Bluestem in the more humid portions of this area. Where the rainfall is less than 15 inches, the Baart variety is superior to Pacific Bluestem, and in parts of the drier sections Hard Federation is promising.

In the irrigated sections of Utah and southern Idaho Pacific Bluestem is considerably outyielded by the Dicklow variety, and results to date indicate that it will be exceeded in yield still more by the Federation variety.

Pacific Bluestem was for many years considered the best milling and baking wheat grown in the Pacific Coast States. Since the introduction of hard red winter and hard red spring varieties, within the past 20 years, it has lost this leading position. Among the common white varieties it now is inferior to more recently introduced varieties, including Baart, Bobs, Bunyip, Federation, Hard Federation, and White Federation.

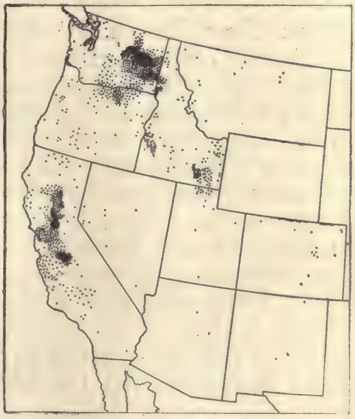

FIG. 6.—Outline map of the western United States, showing the distribution of Pacific Bluestem wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 1,363,400 acres.

MEXICAN BLUESTEM.

The Mexican Bluestem variety is very similar to Pacific Bluestem. It differs only in being slightly shorter and earlier and in having chaff somewhat of a bronze color.

This variety was obtained from Mexico by the Washington Agricultural Experiment Station. It was tested and later distributed from the Western Washington Experiment Station at Puyallup, Wash. It is now grown to a small extent in two counties in western Washington. Mexican Bluestem has proved to be a high-yielding variety in this locality, where it is grown from both fall and spring sowing. The appearance of the kernel of Mexican Bluestem is about the same as that of Pacific Bluestem, so it probably is about equal to that variety in milling and baking qualities.

BUNYIP.

The Bunyip variety is much earlier and shorter than Pacific Bluestem and has a slightly harder kernel. The heads are broad but tapering, and the chaff is yellowish white with brown stripes. These brown stripes make the heads appear brown in the field. Bunyip is a spring wheat, but is usually grown from fall sowing in California. Although it is early maturing and short, the straw is not very strong, and it sometimes lodges.

Bunyip originated from a cross between the Rymer and Maffra varieties made by William Farrer, of New South Wales, Australia, in 1897. It was first introduced into this country by the United States Department of Agriculture in 1914. In 1915 the Sperry Flour

Co. obtained a sample of Bunyip from the Australian exhibit at the Panama-Pacific Exposition at San Francisco, Calif. After being tested in comparison with a few other Australian varieties this wheat was distributed by the above-mentioned company in California in 1918. It is now grown to some extent in the San Joaquin and Sacramento Valleys of California, where it has produced good yields. It has proved a better yielder than Pacific Bluestem on lighter and drier soils and is preferred to Baart by many growers because the heads are beardless. Results to date indicate that Federation, Hard Federation, and White Federation will give higher yields than Bunyip. In milling and bread-making qualities Bunyip is superior to both Pacific Bluestem and Baart and to harder kerneled varieties, such as Hard Federation, when grown in low altitudes.

DART.

Dart (Dart's Imperial) differs from Bunyip in having heads which are slightly clubbed at the tip and in having less of the brown color on the chaff. Like Bunyip and Pacific Bluestem, it is a spring wheat, but is grown from fall sowing in California.

Dart originated from a selection made in a field of Purplestraw wheat by Thomas Dart, at Lucindale, South Australia. It is one of the oldest varieties now grown in Australia. The Dart wheat was brought to the United States in 1915, being included in the Australian exhibit at the Panama-Pacific Exposition along with Bunyip and other varieties. It was tested and distributed in California by the Sperry Flour Co., and is now grown to a limited extent in the San Joaquin Valley.

Dart is not quite equal to Bunyip in either yield or quality and should be replaced by the latter variety.

WHITE FEDERATION.

The White Federation variety is short and extremely early. The heads are short, erect, almost entirely free from short beards, nearly square at the tip, and do not shatter easily. Each section of the chaff is wide and thick. The kernels are short, wide, and hard. The straw is stiff, and the leaves are distinctly curled. This variety is very similar to Hard Federation, except in having white chaff, in being slightly taller, and in having slightly softer kernels.

White Federation was selected with Hard Federation from the Federation variety, from which both probably originated by natural crossing. The White Federation was introduced into this country by the United States Department of Agriculture in 1916. It was first distributed in the fall of 1919 in California, from the United States Plant Introduction Station at Chico, Calif. A few hundred acres are now (1922) being grown in California.

White Federation has given good yields in the Sacramento Valley of California, where it apparently is superior, on the higher, lighter, and drier soils, to the other varieties of wheat grown, although Hard Federation is nearly equal to White Federation in yield. Experiments in Oregon and Washington, however, show that White Federation is not quite equal to Hard Federation in yield in that section, and no seed of White Federation has been distributed in that area for commercial growing. In milling and baking qualities White Federation is equal to Hard Federation and superior to all the important white-kerneled varieties commercially grown.

BOBS.

The Bobs variety is distinct in having no short beards at the tip of the heads. The heads are erect and tapering. The kernels are short, very hard, and almost free from hairs at the tip. The variety is early and does not shatter easily.

Bobs was originated by William Farrer, of New South Wales, Australia, in 1896. It is the result of a cross, one parent of which was Gypsum. The variety has been introduced into the United States on several occasions. It is now grown very sparingly in two counties on the coast of California.

Bobs has not produced high yields in the United States. Because of this it has not become well established, and its production should not be increased. It is rather resistant to drought and for that reason sometimes will outyield other varieties. It is easily injured by the formaldehyde and bluestone treatments for smut, and it is difficult to get a good stand from treated seed of Bobs wheat. In milling and baking qualities Bobs is the best of the common white wheats. It is nearly equal to the best hard red spring varieties, such as Marquis.

DEFIANCE.

Defiance (Pringle's Defiance) is a tall, midearly, white spring wheat having mostly slender, tapering heads (Fig. 7, *B*). There is considerable variation in the size and shape of the heads and the number and length of the short tip beards. The kernels are white and of varying degrees of size and hardness, but for the most part are midsized and rather soft. The straw is fairly stiff and not easily lodged on irrigated land. Defiance is rather resistant to the common forms of stem rust which occur along the coast of California, but is very susceptible to the rusts which occur in the northern spring-wheat region. As commercially grown, Defiance is a mixture of several types of beardless white-kerneled wheat.

Defiance was originated from a cross between two wheats known as White Hamburg and Golden Drop, made by Cyrus G. Pringle, of Charlotte, Vt., in 1871. Defiance was first distributed in 1878 by a seed firm and eventually found its way into the western United States. It was not entirely purified before being distributed, but several selections have been made since from the variety.

Defiance is now grown mostly under irrigation in nearly all of the far Western States. It is most important in Colorado, California, Oregon, and Idaho. The distribution of Defiance, including selections from it, is shown on the map in Figure 8. Nearly 200,000 acres of these Defiance strains are grown.

Defiance is best adapted to the humid valleys along the coast of California, where it withstands rust better than most other varieties. It is sown in the fall there as well as to a slight extent in the Willamette Valley of Oregon. It also is fairly well adapted as a spring wheat in the irrigated sections of southern Colorado. Good yields of this variety are obtained from fall sowing also in the Willamette

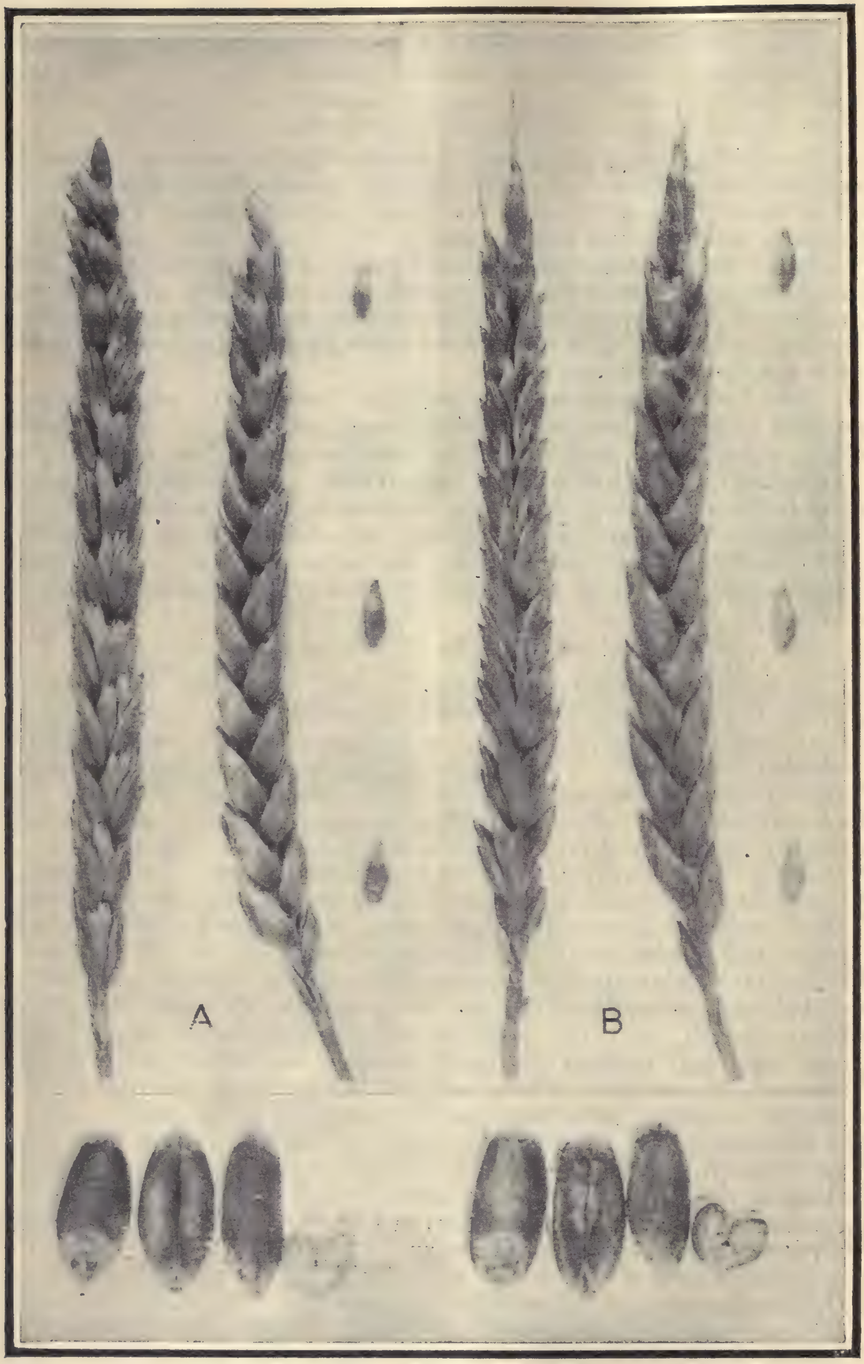

FIG. 7.—Heads, chaff, and kernels of Touse (*A*) and Defiance (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

Valley of Oregon, although it usually is outyielded by White Winter. In northern Colorado, southern Idaho, Utah, and Arizona, Defiance usually is outyielded by other varieties. It is of only fair milling and baking value compared with other common white wheats. Most of it is grown in irrigated and humid sections where wheat becomes starchy, and it consequently is of lower value than varieties grown in drier areas. The growing of the mixed, unselected, and poorer strains of Defiance should be discontinued.

REGENERATED DEFIANCE.

Regenerated Defiance is taller and later and has a larger head than Defiance. The heads are wide and nearly square at the tip (Fig. 9, *B*). The kernels are short, hard, and angular. Regenerated Defiance was selected from Defiance by Prof. A. E. Blount, of the Colorado Agricultural Experiment Station, prior to 1891. It was first distributed from the Colorado station in 1907.

Regenerated Defiance is now grown in Colorado, Idaho, Montana, New Mexico, Nebraska, and Wyoming, but is not of much importance in most of these States.

Regenerated Defiance has given fair yields under irrigation in the States where it is grown. In much of Colorado, Montana, Nebraska, and Wyoming it is usually less productive than Marquis, a hard red spring variety, and Turkey, a hard red winter variety. In Idaho, Dicklow and Federation are better yielding wheats than Regenerated Defiance. It is probable that this variety should be largely replaced by the other varieties mentioned above. As with other hard white wheats, Regenerated Defiance is superior to most of the softer white wheats for milling and bread making. It is inferior, however, to Bobs, Hard Federation, and several others. When grown under irrigation, Regenerated Defiance is inferior for bread making, also to Dicklow and Federation.

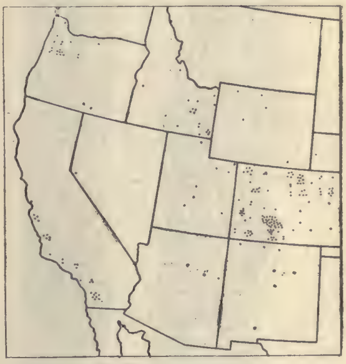

FIG. 8.—Outline map of the western United States, showing the distribution of Defiance and Regenerated Defiance wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 194,400 acres.

EARLY DEFIANCE.

Early Defiance differs from Defiance in being several days earlier and in having no tip beards on the heads. The kernels are rather long and pointed.

Early Defiance is a strain or selection of Defiance which has been distributed in recent years by the Germain Seed Co., of Los Angeles, Calif. It is known to be grown in San Diego County, Calif., and probably is found in other localities. Little is known concerning the yields and quality of this strain of Defiance.

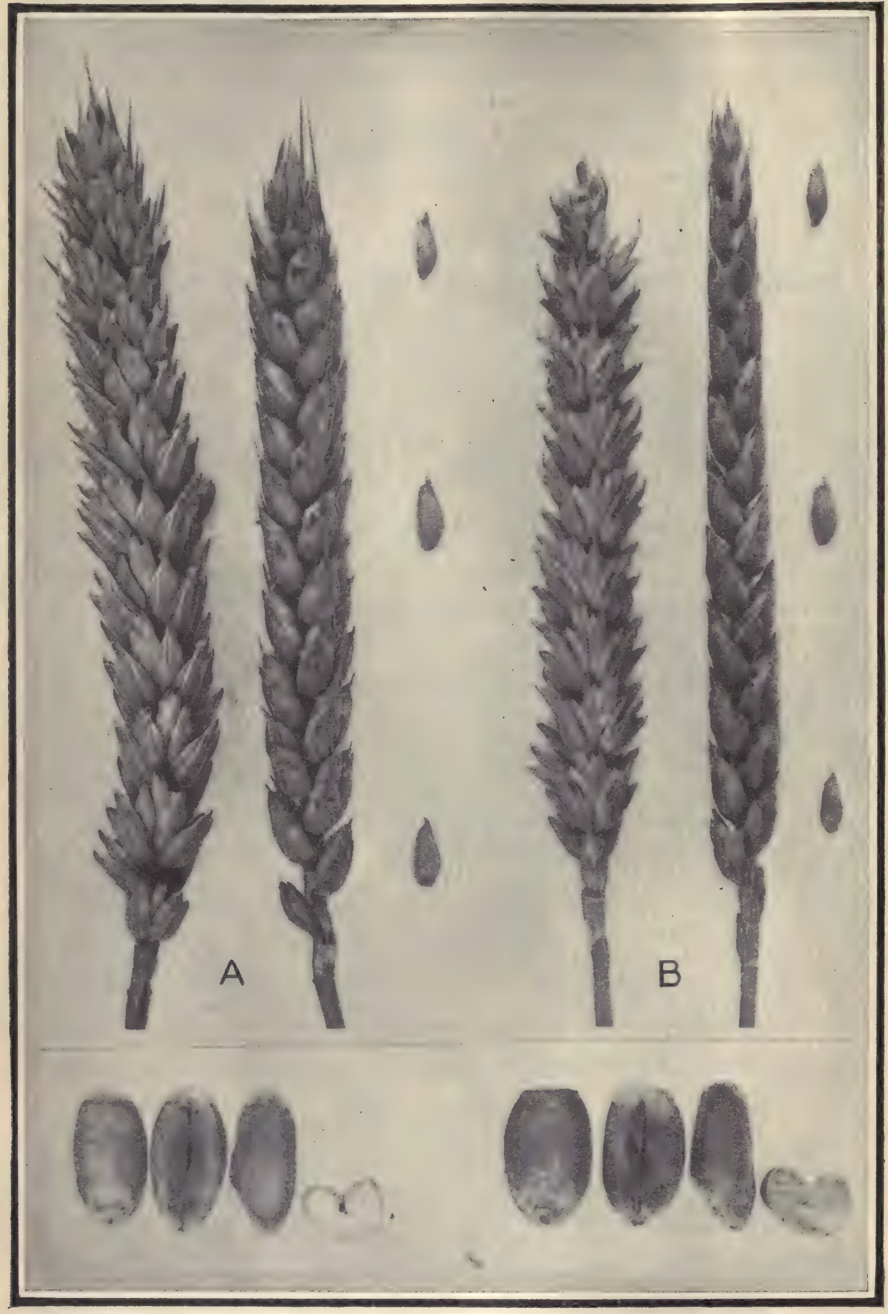

FIG. 9.—Heads, chaff, and kernels of Dicklow (*A*) and Regenerated Defiance (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

COLORADO NO. 50.

Colorado No. 50 is practically identical with Early Defiance, except in having tip beards (Fig. 3, *B*). It is a selection from Defiance made at the Colorado Agricultural Experiment Station, by which it was distributed about 1910. It is an early spring variety.

Colorado No. 50 is now grown at the higher altitudes in several parts of Colorado, where it appears to be well adapted. In milling and baking value it probably is about equal to Regenerated Defiance.

LYNN.

Lynn (Lynn Rust Proof) differs from Defiance in having a square head and harder kernels. It also shows some resistance to rust in California.

Lynn was selected from a field of wheat on the farm of Lynn Bros., of San Luis Obispo, Calif., and distributed by them in the vicinity, where it is now grown to a considerable extent.

Because of its resistance to rust under California conditions, Lynn is adapted to growing in the coastal districts of that State, where rust sometimes occurs. It probably will not outyield other varieties under favorable conditions, however, even in these sections, and should not be grown elsewhere. No experiments have been made to determine the milling and baking value of Lynn wheat, but to judge by its hardness it should be about equal to Regenerated Defiance.

TOUSE.

The Touse (or White Touse) variety differs from Defiance chiefly in having softer kernels and weaker straw. The heads are long, open, and tapering, and very fragile at maturity (Fig. 7, *A*). The kernels, which are easily shattered from the heads, are long, slender, and soft. It is a spring wheat.

Touse is an old variety, having been grown in Utah as early as 1870. Its history is undetermined, but it probably is of French origin.

Touse is not very important. It is grown on a small scale in Arizona, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming. About 20,000 acres were grown in 1919. Because of its weak straw, much of the Touse wheat is grown in a mixture with club varieties to prevent lodging.

It has not given high comparative yields in any section where it is grown. It should be entirely replaced by other varieties of common white wheat or by wheats of other classes. Touse wheat is quite soft and probably is of low milling and baking value.

NEW ZEALAND.

The New Zealand variety (known also as Ninety-Day and Ruby) differs from the other varieties previously described in having larger kernels. New Zealand wheat resembles Pacific Bluestem rather closely, but the heads are slightly longer and more open and the kernels are longer. The glumes or chaff are narrower than on Pacific Bluestem and of a lighter color.

New Zealand wheat has been grown in Utah for more than 30 years. Its origin is unknown, but from the best available evidence it does not appear to have come from New Zealand and is probably of European origin.

It is grown throughout Utah and in several counties in southern Idaho, but only a small acreage is now sown.

It has not shown high yields in comparison with other varieties where it is grown. It should be replaced by other varieties, such as Federation, Dicklow, and Pacific Bluestem. New Zealand is of fair milling and baking quality, but is not superior to a number of other varieties described in this bulletin.

GYPSUM.

Gypsum (Colorado Special) wheat differs from the common white spring varieties thus far described in having heads which are somewhat clubbed at the tips (Fig. 5, *B*). The heads are short and beardless. The kernels are of medium size, soft to semihard, and have a rough seed coat.

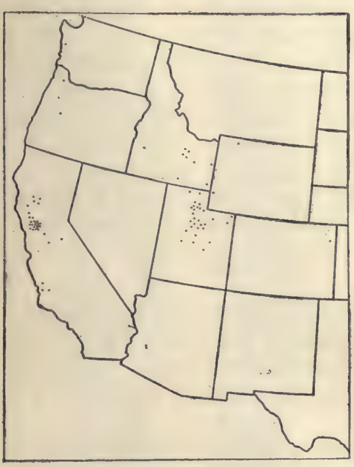

FIG. 10.—Outline map of the western United States, showing the distribution of Surprise wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 60,900 acres.

Gypsum was originated by hybridization by Prof. A. E. Blount, of the Colorado Agricultural Experiment Station, during the early eighties. It was distributed in Colorado, where, in a few years, its identity was lost. Since 1912, and perhaps earlier, it has been grown on the dry lands of the Rexburg Bench in southeastern Idaho. It is now grown in at least five counties in eastern Idaho under the name Colorado Special.

Gypsum wheat apparently does not yield more than Pacific Bluestem and Marquis, the latter a hard, red spring variety. Much of eastern Idaho is better adapted to winter wheats, such as Turkey, a hard red winter variety, and Goldcoin, a common white winter wheat. Gypsum apparently is of fair milling and baking quality, but not better than several other common white varieties.

SURPRISE.

Surprise (Pringle's Surprise) is known chiefly by the following names: Australian Club, Bay, California Club, California Gem, Excelsior, Golden Gate Club, Imperial Club, Mormon Club, Pride of California, Silver Chaff, Silver Club, Smith Club, University Gem, and White Russian. It has erect, compact heads, with clubbed tips, but it is not a club wheat. The kernels are of about medium size, but appear flattened and are soft. It is a late-maturing spring wheat. There is a considerable variation in the plants, heads, and kernels of Surprise, indicating that it contains several types.

Surprise was originated by Cyrus G. Pringle, of Charlotte, Vt., the originator of Defiance. It is the result of a cross between Chile

Club (Big Club) and a variety of common wheat which was called Michigan Club. After being increased, the entire supply of seed was sold as Pringle's Surprise to the United States Commissioner of Agriculture for distribution. It proved to be adapted only to the western part of the United States. In the course of time many other names were applied to it, and the identity of the variety was almost lost. At the time it was distributed Surprise had not been purified, and it still lacks uniformity. It is now grown partly under irrigation in California, Idaho, Oregon, Utah, Washington, and Wyoming. About 60,000 acres were grown in 1919 (Fig. 10).

Because of its late maturity Surprise is best adapted to irrigated lands and to cool humid sections. Under such conditions it is a good-yielding variety of fair milling and baking quality. In the irrigated districts of Utah and Idaho, however, it is now being displaced and should be replaced by Dicklow and Federation. higher yielding varieties of better quality.

DICKLOW.

Dicklow wheat (known also as Dago, Hawley, Holly, Jim Holley, and Richard Low) is almost identical with the Surprise variety from which it was selected. It is pure, however, and represents one of the types found in Surprise. Dicklow can be distinguished from Surprise by the heavy white waxy bloom on the stems just before ripening. It is a late-maturing spring wheat. Its heads are quite clubbed at the tip (Fig. 9, A). The kernels of Dicklow are somewhat flattened and soft.

Dicklow was selected from a field of Surprise (or California Club) in Utah County, Utah, by Richard Low. It spread rapidly over northern Utah. In 1912 and 1913 it was distributed in southern Idaho, where it is now the most important spring wheat grown under irrigation.

At present Dicklow is grown principally in Idaho and Utah, with smaller acreages in Wyoming and Montana. More than 160,000 acres of Dicklow wheat were grown in 1919 (Fig. 11). The section of heaviest production is in the vicinity of Twin Falls, Idaho.

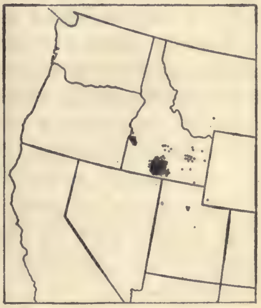

FIG. 11.—Outline map of the Pacific Northwest. showing the distribution of Dicklow wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 164,600 acres.

On the irrigated lands of southern Idaho and northern Utah, Dicklow has outyielded all other varieties commercially grown. In experiments during the past three years (1919 to 1921) Federation has outyielded Dicklow and gives promise of replacing it. In the district just mentioned these two varieties should be grown to the exclusion of all others. The chief objections to Dicklow are the injury from loose smut and the shattering of the heads. The latter is largely overcome in Federation.

Outside of the district mentioned above, Dicklow is not especially promising even under irrigation, and because of its late maturity it is not adapted to the dry-land sections.

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In milling and baking qualities Dicklow is inferior to several of the better spring varieties of common white wheat grown on the dry lands; but, with the exception of Federation, Dicklow is superior to the white wheats grown under irrigation.

QUALITY.

Quality (Burbank's Quality) is an early-maturing spring wheat. The heads are beardless, erect, tapering, of medium length, and have smooth white chaff. The kernels are rather short and hard and shatter from the heads very easily at maturity. While Quality is a spring wheat, it can be grown from fall sowing in mild climates such as that of California.

Quality was first distributed by Luther Burbank, of Santa Rosa, Calif., in 1918. The origin of this variety has not been announced. It is grown now on a small scale in California, Montana, and Oklahoma, and in scattering trials in many other States.

In the Sacramento Valley of California, Quality is outyielded by nearly all varieties now grown there. It shatters so easily when ripe that it can not be harvested with the combined harvester without losing much of the grain. In Montana, where Quality is grown as a spring wheat, it is outyielded by Marquis (the principal hard red spring wheat) and several varieties of common white wheat.

Spring wheat is poorly adapted to the climatic conditions of Oklahoma, so that winter wheat is grown almost exclusively. This is true also of Kansas, Missouri, Texas, and all of the Corn Belt States. Quality can not be successfully grown from fall sowing in any of the sections mentioned, because it is not a winter wheat and can not survive ordinary winter temperatures.

Quality is of good milling and baking value. It apparently is inferior, however, to Baart, Bunyip, Bobs, Hard Federation, and White Federation, besides many hard red spring and hard red winter varieties.

WHITE FIFE.

The White Fife variety has slender, tapering heads and hard white kernels. It is of medium height, is midearly in maturing, and grown only as a spring wheat.

The origin of White Fife is not known, although it is thought to have been separated from Red Fife, a hard red spring variety. It has been grown in the United States since 1878, or earlier, and at the present time is known to be grown very sparingly in Minnesota, Nebraska, and South Dakota.

White Fife formerly gave good yields in Canada, but has not been able to compete with Marquis. In the United States White Fife also has not yielded as well as Marquis in the States producing hard red spring wheat and should no longer be grown in that section.

White Fife is of fair milling and baking value, but is not equal to the better hard red spring varieties.

RINK.

The Rink variety has wide flat heads and rather small soft white kernels. Although the heads are considered beardless, short, sharply incurving beards occur throughout the length of the heads. It is a rather late maturing spring wheat.

The origin of Rink is not known. It has been grown in Washington County, Oreg., at least since 1909. It is now grown in that and adjacent counties in the Willamette Valley of Oregon, from both fall and spring sowing.

Rink has not produced as high yields from either fall or spring sowing as other varieties grown in the same section. In milling and baking qualities it is about equal to White Winter and other varieties of soft white wheat.

PILCRAW.

The Pilcraw (Pilcraw Enormous) has erect, compact heads, which are distinctly clubbed at the tip. Although beardless, the upper meshes of each head have several short beards varying in length from half an inch to more than 1½ inches. The kernels are large, thick, plump, humped, and soft. Pilcraw most closely resembles Surprise, but differs from it chiefly in having larger kernels and longer tip beards.

The origin of Pilcraw has been traced to a plant found growing along the roadside in Napa County, Calif. The progeny of this plant was increased by Hugh A. Crawford, of Napa, Calif., from 1913 until 1917, when it was first distributed. The variety is now grown sparingly in Napa and Sacramento Counties, in California.

Little is known concerning the yielding ability or quality of Pilcraw wheat, but apparently it does not yield more than other varieties grown in the same section, as its acreage has not increased.

Section 3.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED; WINTER WHEATS.

The wheats grouped in section 3 include six white-kerneled winter varieties, some of which are grown in both the eastern and the western parts of the United States. They are grown only from fall sowing. All of these varieties have soft kernels of rather low milling and baking value.

GOLDCOIN.

The Goldcoin (Gold Coin) variety is known by many names, including Abundance, American Banner, Clawson, Eldorado, Fortyfold, Gold Bullion, Golden Chaff, Gold Medal, Goldmine, Improved No. 6, International No. 6, Junior No. 6, Klondike, New American Banner, New Soules, Niagara, Number 6, Oregon Goldmine, Plymouth Rock, Prizetaker, Prizewinner, Rochester No. 6, Soules, Superlative, Twentieth Century, White Century, White Clawson, White Eldorado, White Rock, White Russian, White Soules, White Surprise, and Winter King. In the Western States it is almost universally known as Fortyfold. In New York it is usually called Number 6. Some of the names listed above are for supposedly selected strains of wheat, but none of them can be distinguished from the bulk parent variety.

The Goldcoin wheat has erect, compact heads which have a golden-brown chaff. The heads usually are distinctly clubbed at the tip (Fig. 12, *B*). The straw or stems of Goldcoin are purplish or reddish at maturity. The kernels are midsized, soft, and white. Most of the kernels have a rim or collar around the brush (tuft of hairs

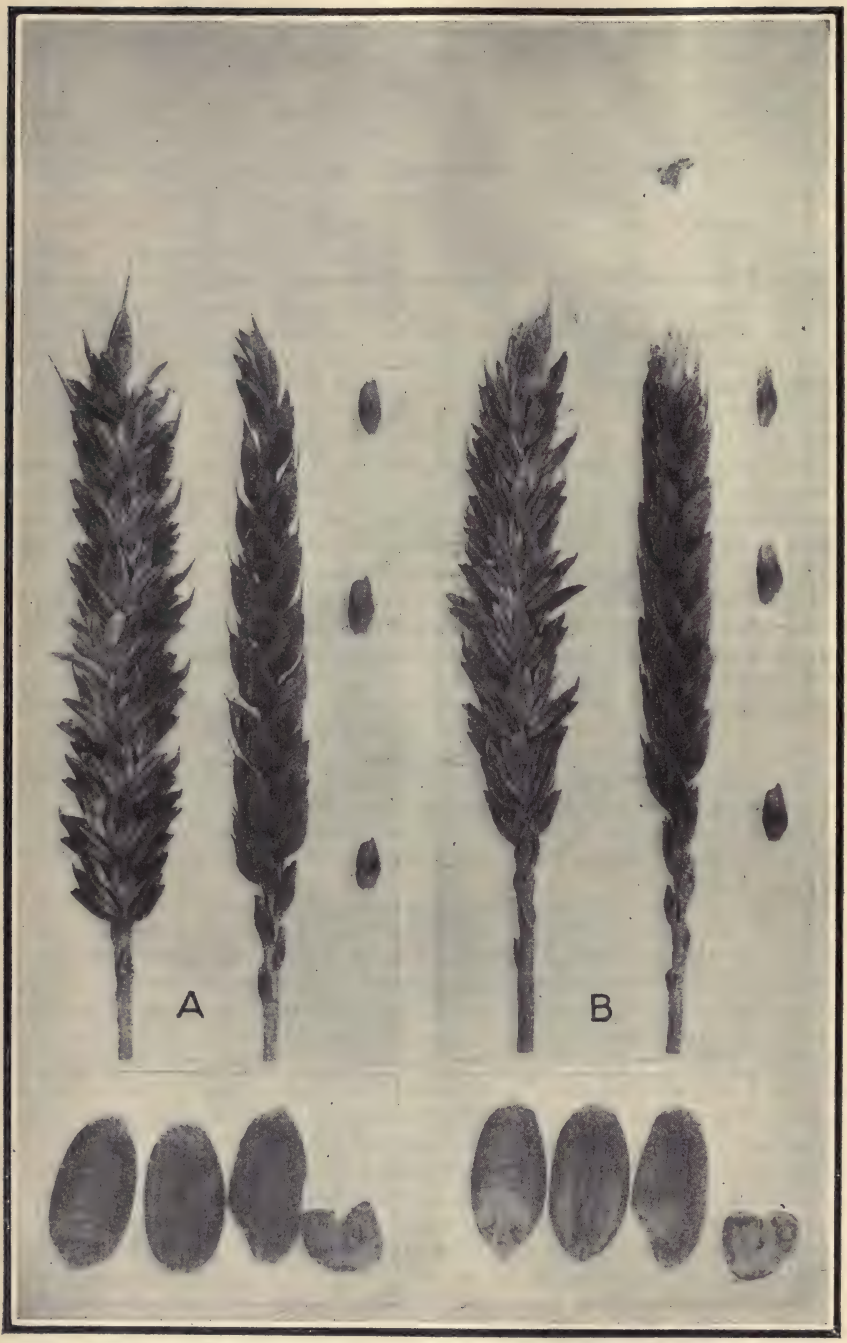

FIG. 12.—Heads, chaff, and kernels of Dawson (*A*) and Goldcoin (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

at the tip). The kernels are rather easily shattered from the heads at maturity. It is grown only as a winter wheat.

Several conflicting stories of the origin of Goldcoin and its various strains have been announced. The New Soules wheat, identical with Goldcoin, has been known since 1840, and the Clawson since 1865. Both of these originated from plants found in fields of other varieties of wheat. The wheat which later became known as Goldcoin originated from a head found in a field of Diehl-Mediterranean wheat by Ira M. Green, of Avon, N. Y., about 1890. The variety was distributed by several seedsmen.

Goldcoin wheat is now grown in two widely separated areas, one being in the humid section of the North Atlantic States and the other in the Pacific Northwest. In the latter area it is grown both on irrigated and nonirrigated lands and in both subhumid and semiarid sections. The variety is most important in the following States in the order named: Washington, New York, Oregon, Michigan, and Idaho. In 1919 nearly 1,000,000 acres of Goldcoin were grown in the United States (Fig. 13). It is second in importance among the common white wheats.

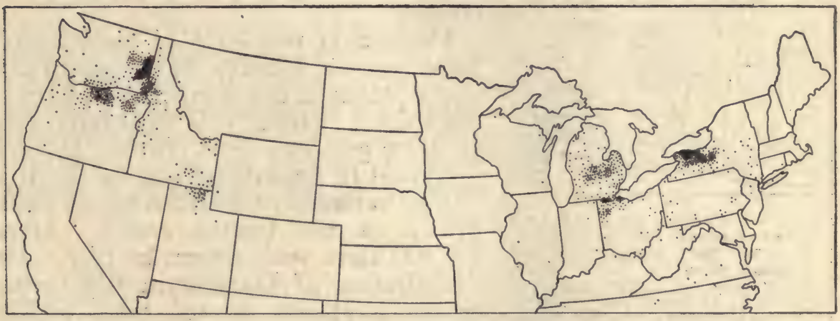

FIG. 13.—Outline map of the northern United States, showing the distribution of Goldcoin wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 947,000 acres.

While Goldcoin is a fairly productive wheat, it usually does not outyield all other varieties grown in the same sections. There are certain districts in Oregon and Washington, however, where Goldcoin still is the leading variety. Most important of these districts are the southern part of the Columbia Basin, the Grande Ronde Valley of Oregon, and the section around Spokane, Wash. In Oregon, in the higher and drier parts of the southern Columbia Basin, it is being partly replaced by Turkey, a hard red winter wheat, and in the more favorable localities by the higher yielding club wheat, Hybrid 128. Outside of these areas it should be entirely replaced by Turkey in the Western States.

In New York, Michigan, Ohio, and Pennsylvania, Goldcoin has given good yields in comparison with the soft red winter varieties. In most of Michigan, however, Red Rock, a soft red winter variety, is more productive; and in most parts of the other States Dawson has given higher yields than Goldcoin. The acreage of Goldcoin, therefore, could well be reduced in the Eastern as well as in the Western States.

Goldcoin is one of the poorer varieties of common white wheat for bread making. It is slightly inferior to Dawson. For making starchy flour for pastry and for making certain whole-wheat foods, Goldcoin is very satisfactory.

DAWSON.

Dawson (Dawson Golden Chaff) also is called Golden Bronze, Golden Chaff, Improved Amber, and White Winter. Dawson differs from Goldcoin chiefly in having white or yellow straw instead of purple and in having a square-tipped instead of a clubbed head (Fig. 12, *B*). The kernels also do not have the collar or rim around the brush. It is the most winter hardy of the white wheats.

The Dawson variety originated from a plant found in a field of Clawson wheat in 1881 by Robert Dawson, of Paris, Ontario, Canada. After it was found to be a high-yielding variety at the Ontario Agricultural Experiment Station the growing of Dawson was rapidly increased.

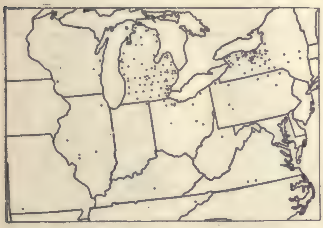

FIG. 14.—Outline map of the north-central United States, showing the distribution of Dawson wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 125,500 acres.

Dawson is not only of considerable importance in Canada, but is grown also in 13 States in the northeastern part of the United States. It is most important in Michigan and New York. Dawson is second in importance among the true winter varieties of common white wheat grown in the United States. About 125,000 acres were grown in 1919. The distribution of Dawson in the United States is shown on the map in Figure 14.

Dawson wheat has outyielded nearly all other varieties in New York, Pennsylvania, and Ohio. It also has given good yields in Michigan, but is outyielded in that State by the Red Rock variety. Being a white wheat not desired for grinding into bread-making flour, Dawson has not been as widely grown as many of the red wheats. Like Goldcoin, it is grown for special markets.

Dawson is superior to Goldcoin and most of the other common white winter wheats in milling and baking qualities, but it is not equal to the better varieties of soft red winter wheat.

HONOR.

Honor can not be distinguished from the Dawson variety. It is slightly hardier, has a stronger straw, and produces better yields than Dawson, however. This wheat was selected from Dawson at the Cornell University Agricultural Experiment Station. After trials lasting several years at the experiment station and on farms in New York, the Honor wheat was offered for sale in 1920. It is now grown to some extent in that State.

Honor has outyielded Dawson in comparative tests in New York and apparently is the highest yielding wheat grown there.

ARCADIAN.

Arcadian (Early Arcadian) is shorter and has a stiffer straw than either Goldcoin or Dawson. The heads are short, compact, and extremely clubbed at the tip. The straw is white. The grains are short, broad, and soft. It originated from a cross between Genesee Giant and Red Clawson, made by A. N. Jones, of Newark, N. Y., in 1895.

This variety apparently is not grown in the eastern part of the United States, where it originated, but in recent years it has been observed in two counties in the south-central part of Washington. Little is known concerning the yields or quality of Arcadian, but apparently it is not equal to many of the more commonly grown varieties of common white wheat.

WINDSOR.

Windsor (Extra Early Windsor) is similar to Goldcoin. The heads, however, are oblong and nodding rather than clubbed and erect, and the kernels do not have the collar around the brush. The origin of Windsor is not known, but it has been under cultivation for at least 30 years. It is now grown to a very limited extent in Michigan. The yields of Windsor are mostly lower than those of Dawson, so that the growing of this variety probably should be discontinued. Apparently it is not superior to the other common white winter varieties in milling and baking qualities.

KOFOD.

The Kofod (Koffoid) wheat differs from the other white winter wheats described under this section in having tapering heads. The heads are nodding and of a rather yellowish brown color. The straw is white, slender, and rather weak. The kernels are rather long and quite soft and chalky. The variety is not uniform in type.

An interesting but mythical history of Kofod has been announced. The wheat is reported to have been discovered in some ancient Indian mounds in Utah County, Utah, about 1870. According to the story, some of the wheat was sown and grew. In reality, wheat loses its vitality within 20 years, and usually much more quickly, so that the above story is hardly plausible. In 1875, Hans C. Kofod obtained seed of this wheat from a grower, and eventually the variety became known as Kofod or Koffoid.

The Kofod variety is now grown as a winter wheat, mostly on dry land in central and southwestern Utah. Only a few thousand acres are grown. The yields of Kofod are distinctly less than those of Turkey, a hard red winter variety. The Kofod is still grown, principally because it is beardless and the straw is more satisfactory for stock feed than the straw of Turkey. Kofod is a soft white wheat of medium milling and baking quality, and a special market has been developed for it in Utah. In general, however, the returns per acre from Kofod are considerably less than from Turkey. Unless the straw is to be used for feed, Kofod wheat should not be grown. It is of little promise outside of Utah, as it is outyielded by several other varieties.

Section 4.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED; SPRING WHEATS.

The varieties in section 4 differ from those of section 3 in being spring wheats. The section includes five varieties which are of little commercial importance as yet, but two of them are quite promising.

FEDERATION.

The Federation variety is a short, fairly early spring wheat, having erect, oblong to slightly tapering heads and brown chaff. The heads are stiff, rather compact, and have almost no tip beards (Fig. 15, *A*). The kernels are white, rather short, and usually soft. Federation is a spring wheat, but can be grown from fall sowing in mild climates like that of California.

Federation originated from a cross between the Purplestraw and Yandilla varieties made by William Farrer, of New South Wales, Australia. Federation is now the leading wheat variety in Australia. This variety was introduced into the United States in 1914 by the United States Department of Agriculture. After being tested in the Pacific Coast States for several years, it was first distributed to farmers in Oregon in the spring of 1920 from the Sherman County substation, Moro, Oreg. About 1,000 acres were grown in Oregon in 1922. Small acreages also were grown in Idaho and Washington.

Federation has given exceptionally high yields under irrigation in southeastern Oregon and southern Idaho. It doubtless should replace all other spring varieties, including Dicklow, which are grown in these districts. Federation also has shown considerable promise on the dry lands of Oregon and California. It probably is somewhat inferior to Hard Federation for the dry lands.

The Federation wheat is of good milling and baking quality and is superior to Dicklow when grown under irrigation. It is not equal to the harder kerneled varieties of common white wheat, such as Bobs, Hard Federation, and White Federation, when grown on dry land.

HARD FEDERATION.

Hard Federation differs from Federation chiefly in being shorter and earlier and in having harder kernels. The heads of Hard Federation are erect, short, stiff, and compact, and practically free from short beards (Fig. 15, *B*). The kernels of Hard Federation are short, broad, thick, quite hard, and translucent. The straw is white and stiff and the leaves distinctly curled. Like Federation, Hard Federation is a true spring wheat, but is grown from fall sowing in California.

Hard Federation was selected from Federation about 1908 by J. T. Pridham, at the Cowra Experiment Station in New South Wales, Australia. It was first introduced into the United States by the United States Department of Agriculture in 1915 and was first distributed in 1920 to farmers of Oregon and California from the experiment stations at Moro, Oreg., and Chico, Calif. Further distributions have been made since, and in 1922 about 5,000 acres were grown in Oregon and about 1,000 acres in California.

Hard Federation has outyielded all other spring varieties on the dry lands in the Columbia Basin of Oregon. It also has given ex-

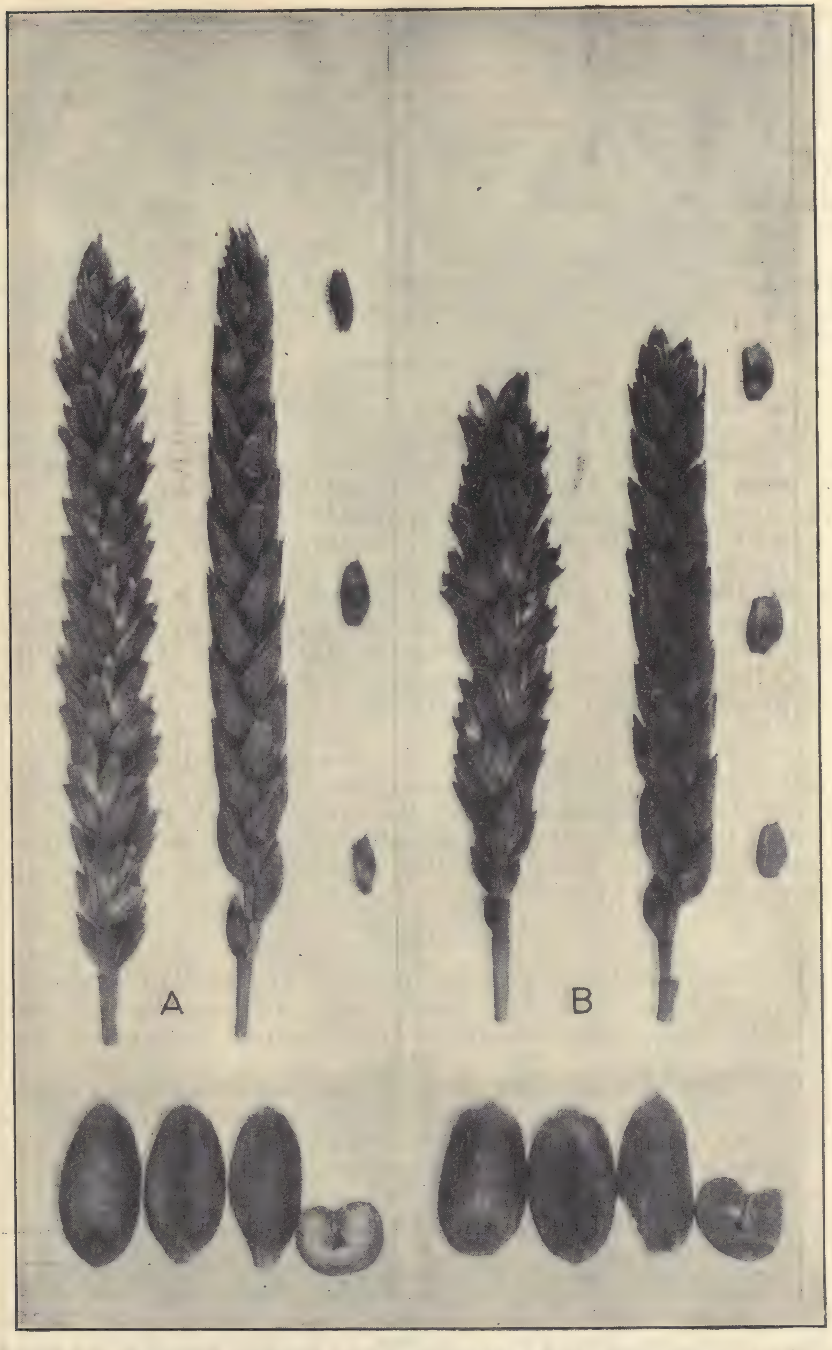

FIG. 15.—Heads, chaff, and kernels of Federation (*A*) and Hard Federation (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

cellent yields as a spring wheat on dry lands in other parts of Oregon and as a winter wheat in the San Joaquin and Sacramento Valleys of California. Hard Federation also has yielded well in central Montana. It probably will soon be an important variety in many of the semiarid sections of the Pacific Coast States and should partly replace such varieties as Pacific Bluestem, Baart, and Sonora. Hard Federation is not adapted to weedy or wet lands. It will not produce well in the presence of stem rust, and it is susceptible to bunt, or stinking smut.

In milling and baking qualities Hard Federation is superior to almost all of the common white wheats except Bobs. It is nearly equal to the best varieties of hard red spring wheat for flour and bread making.

JOHN BROWN.

The John Brown wheat is tall and erect. The heads are long, rather slender, and usually tapering. The kernels are midsized and soft. This variety originated from crosses between several varieties made by William Farrer, of New South Wales, Australia, in 1896. The John Brown variety was first introduced into the United States in 1909 by F. D. Farrell, who was then superintendent of the Nephi substation, Utah. Later introductions were made by the United States Department of Agriculture and the Wyoming Agricultural Experiment Station. After a preliminary trial the Wyoming station secured a bushel of this wheat in 1911, and following further trials the John Brown wheat was distributed to farmers in Wyoming for growing under irrigation. It has not become commercially important.

John Brown has not yielded as well as several hard spring varieties in Wyoming or in the Pacific Coast States. It should no longer be grown, as it is doubtful whether the variety is well adapted to any part of the United States. The milling and baking quality of this wheat probably is lower than that of several other common white wheats previously mentioned.

ALLEN.

The Allen (Red Allen) variety is known also as Wolf Hybrid. It is tall and late and has long, slender, open, tapering, inclined heads (Fig. 16, *A*). The kernels are white, of medium size, and are semihard.

The origin of Allen wheat is not known, but it has been grown in Washington for at least 20 years. It is now sparingly grown also in eastern Oregon and northern Idaho.

Partly because of its later maturity, this variety has given lower yields than other spring wheats grown in the same districts. It probably should be entirely replaced by Baart, Federation, or Pacific Bluestem.

FOISY.

The Foisy variety (known also as Oregon Golden Chaff, Oregon Red Chaff, and Red Chaff) differs from Allen in having erect, clubbed heads instead of inclined tapering heads (Fig. 16, *B*). The heads are long and open and the chaff a dark-brown color. The plants are tall and late. The kernels are small, white, and soft. It

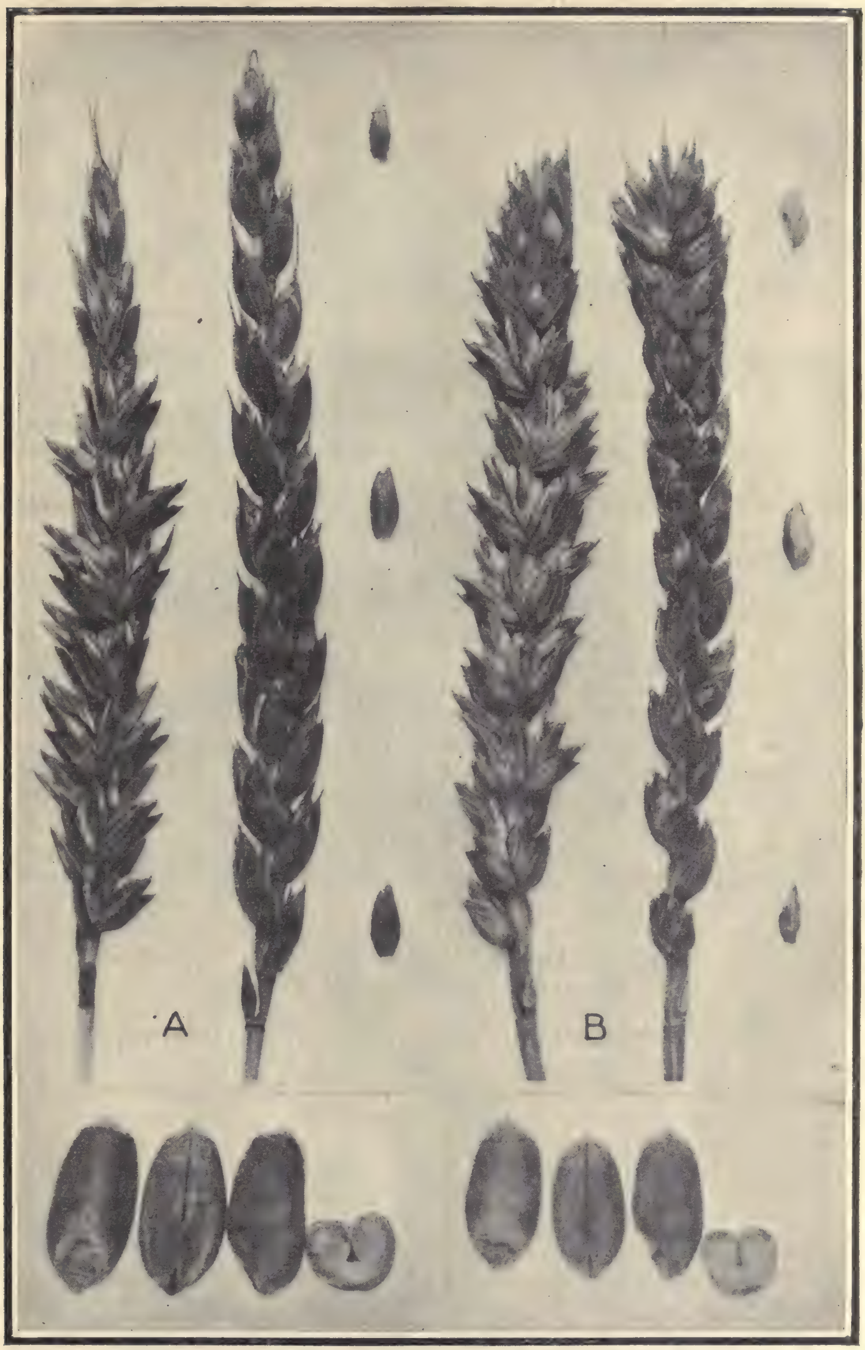

FIG. 16.—Heads, chaff, and kernels of Allen (*A*) and Foisy (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

is grown from both fall and spring sowing, but is a true spring wheat.

The Foisy variety originated from a plant found about 1865 in a field of wheat on the farm of M. G. Foisy, near West Woodburn, Oreg. The wheat was increased and distributed in the vicinity. It is now grown in 11 counties in western Oregon. More than 40,000 acres were grown in 1919.

Because of its late maturity, Foisy is adapted only to cool humid sections. It is not likely to be productive, therefore, outside of the districts where it is now grown. Even in that section it usually is outyielded by other varieties, such as White Winter. On wet and poorly drained land it is superior to White Winter.

Section 5.—HEADS BEARDLESS; CHAFF VELVETY, WHITE; WINTER WHEAT.

Section 5 contains only one variety of wheat grown commercially in the United States, and it is of relatively small importance.

SILVERCOIN.

The Silvercoin (Hansen) variety has beardless heads, with velvety or hairy white chaff and soft white kernels. It is of medium height and maturity. The heads are nearly erect and distinctly clubbed at the tip. The kernels are rather short and wide. Silvercoin can be grown only from fall sowing.

This variety originated from a plant found in a field of mixed Goldcoin and Sonora wheats on the farm of Eph. Hansen, near Mendon, Utah. It is probably the result of natural crossing between Goldcoin and Sonora. The wheat was increased and distributed in the vicinity and is now grown in Box Elder and Cache Counties, in Utah.

Little is known concerning the value of Silvercoin. It probably yields less than the hard red winter variety, Turkey, in the district where it is grown, and it also is of lower milling and baking value.

Section 6.—HEADS BEARDLESS; CHAFF VELVETY, WHITE; SPRING WHEATS.

Section 6 consists of two varieties of minor importance grown commercially in the United States. The varieties in this section differ from the variety contained in section 5 in being spring wheats.

INDIAN.

The Indian variety is identical with Sonora, described later, except in having white chaff. It occurs as a common mixture in Sonora, but has been separated and grown alone for at least 40 or 50 years. The name may have arisen from the fact that this wheat is grown by Indians. It is now grown to a limited extent in Utah and Arizona. As Indian wheat can not be distinguished from Sonora except in chaff color, the statements of the yield and quality of Sonora (under section 7) apply equally to Indian.

JUMBUCK.

Jumbuck has beardless heads with velvety white chaff and semihard to hard white kernels. The heads are erect and slightly tapering. It is a spring wheat, but is grown from fall sowing in California.

The Jumbuck variety originated from the intercrossing of three wheats by William Farrer, of New South Wales, Australia. It received its name "Jumbuck" (a country name for a sheep) because of the woolly appearance of the chaff. It was introduced into the United States from New South Wales about 1911 by the California Agricultural Experiment Station. This station later distributed small quantities for trial to farmers in California, but its commercial culture is very limited.

In recent experiments Jumbuck has not given as good yields as several other varieties in California. From present information it is not to be recommended. Milling and baking tests with Jumbuck have shown it to be inferior to several other common white wheats.

Section 7.—HEADS BEARDLESS; CHAFF VELVETY, BROWN OR RED; SPRING WHEATS.

Two very distinct varieties comprise the commercial wheats in this section. One of them is rather important.

SONORA.

The Sonora variety (known also as Ninety-Day, Red Chaff, and White Sonora) is early and rather short and has erect, short, compact, oblong heads (Fig. 17, *A*). The kernels are small, soft, and white. The outer chaff on each mesh of the heads of Sonora has longer points or beaks than those of any other variety of beardless wheat grown in the United States. Sonora is a spring wheat, but most of it is grown in California and Arizona from fall sowing. As previously mentioned, Sonora is identical with the Indian variety, except in chaff color.

The origin of Sonora wheat is not known. It was grown in Sonora, Mexico, at an early date, and was reported to have been brought to California by the Spanish Fathers 100 or 150 years ago. It is the oldest variety grown in California and Arizona. It still is the leading wheat grown by the Indians in those States. In recent years samples of wheat identical with Sonora have been obtained from South Africa, but the previous history of these lots is unknown.

The Sonora variety is now grown in varying quantities in all of the States west of the Great Plains area. About 240,000 acres of this variety were grown in the United States in 1919 (Fig. 18). Nearly four-fifths of this was grown in California, the upper San Joaquin Valley producing most of it.

Because of its earliness, Sonora wheat often gives high yields under unfavorable conditions. Under most conditions in California, Arizona, and Utah, Sonora is outyielded by Baart and frequently by other varieties, such as Pacific Bluestem, Defiance, and Dicklow. Sonora appears to be the highest yielding variety in Tulare and adjacent counties in California. It often gives high yields in south-

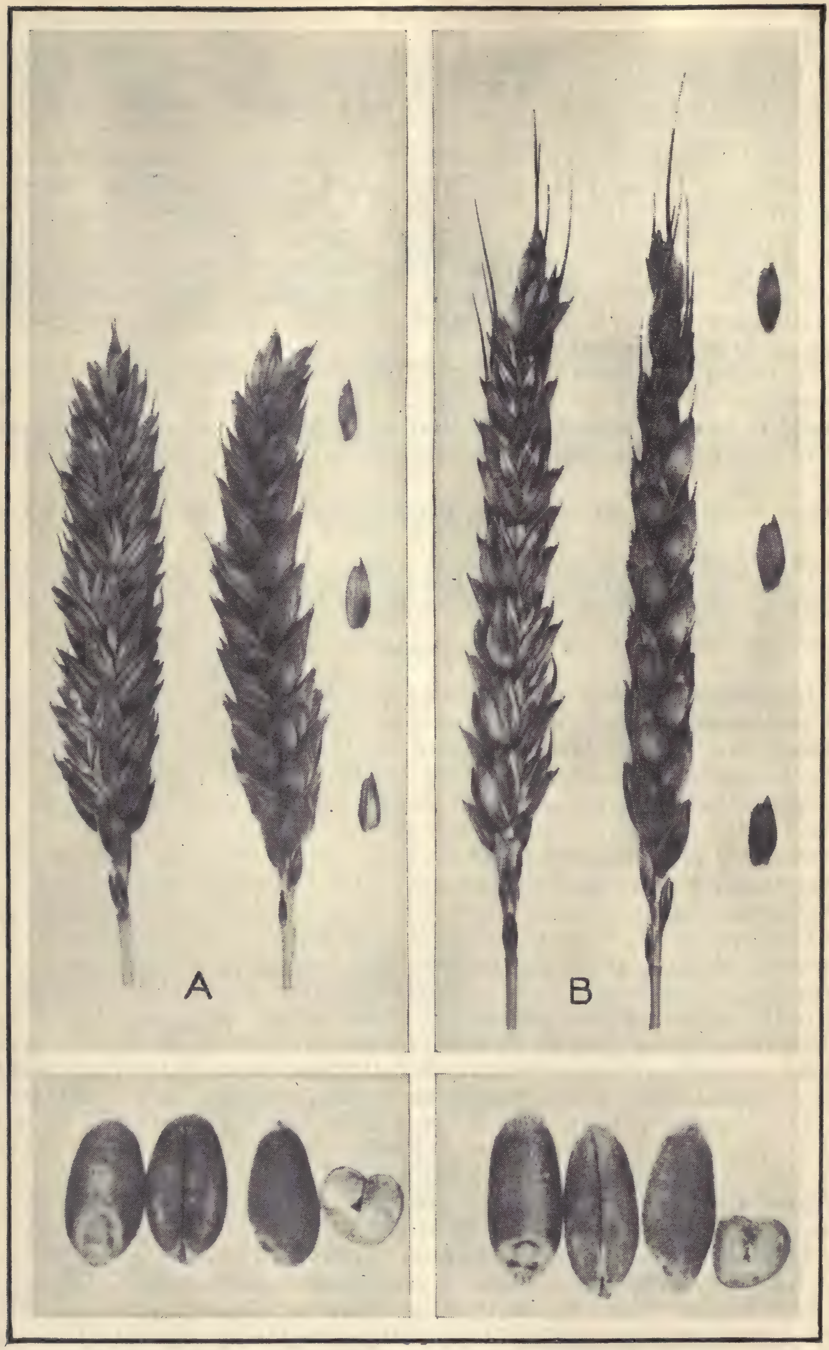

FIG. 17.—Heads, chaff, and kernels of Sonora (*A*) and Galgalos (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

ern Arizona, especially in unfavorable seasons. Outside of portions of California and Arizona, Sonora is outyielded by several other varieties.

The flour from Sonora wheat is not desirable for bread making. as it produces loaves of very poor quality. Much of the Sonora wheat milled is used in the manufacture of crackers, pastries, and breakfast foods. The low quality of Sonora has caused it to be graded with club wheats in the Official Grain Standards.

GALGALOS.

The Galgalos wheat (called also Russian Red and Velvet Chaff) differs from Sonora chiefly in being taller and later and in having longer, looser heads and longer kernels. The heads are inclined, long, slender, open, and tapering (Fig. 17, *B*). The chaff is of a light-brown color. The kernels are rather long, slender, and soft. The straw is weak, so that the plants lodge quite easily. The leaves of Galgalos have a bluish appearance, owing to the presence of white hairs on the surface. Before shooting to head, the plants of Galgalos lie nearly prostrate on the ground like winter wheats, but it is a spring wheat. It will survive rather severe winters, however, when fall sown.

Galgalos was introduced into the United States from the Erivan Government in Transcaucasia, Russia, by the United States Department of Agriculture, in 1903. It was distributed later in California, and small quantities were sent to other States. The wheat is now grown in Oregon and California. It is most important in northern California and in central Oregon. Less than 35,000 acres were grown in 1919.

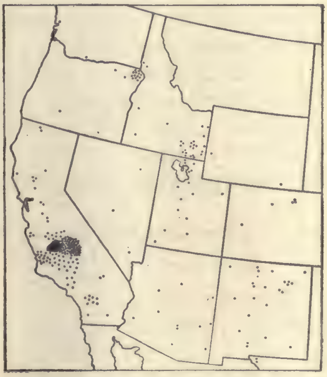

FIG. 18.—Outline map of the western United States, showing the distribution of Sonora wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 243,900 acres.

Galgalos has given rather high comparative yields under dry conditions in several States. Because of its weak straw it is not a desirable variety to grow in many sections. It also would not be suitable for growing in the Great Plains area, because of its white kernels. In the sections of California and Oregon where Galgalos is now grown, it could be replaced by other varieties such as Baart, Hard Federation, and Federation.

Flour from Galgalos wheat produces a fairly high quality of bread. The percentage of flour obtained from Galgalos wheat is relatively low, so that on the whole it is not an especially valuable variety for milling, although it is of good quality for bread making.

Section 8.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), WHITE; WINTER WHEAT.

Only one commercial variety is included in section 8, and it is of little importance.

DEMOCRAT.

Democrat has bearded, tapering, inclined heads, with glabrous white chaff. The kernels are soft, white, and rather slender and pointed. The variety is midearly and tall and is grown only as a winter wheat. Democrat was formerly grown considerably in Ohio. It was obtained by the Ohio Agricultural Experiment Station in 1883 from George Burr, of Lodi, Ohio. The origin of the variety is not known.

Democrat was reported to be grown sparingly in Illinois, New York, Ohio, Pennsylvania, and West Virginia in 1919, when about 6,000 acres were grown.

In comparative experiments Democrat has not yielded as well as other varieties, mostly of soft red winter wheat, grown in the same regions. The small remaining acreage of Democrat should be replaced by other varieties. Little is known concerning its milling and baking qualities, but it does not appear to be especially valuable.

Section 9.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW; SPRING WHEATS.

The wheats of section 9 differ from that of section 8 in being spring varieties. Four varieties in this section are commercially grown.

BAART.

The Baart (Early Baart) wheat is known also as Arizona Baart, Columbia, Diener No. 18, and White Columbia. This variety has slender, tapering, rather open heads and glabrous white chaff (Fig. 19, *B*). The heads and beards are of medium length and sometimes rather short. The kernels are yellowish in color, long, somewhat pear shaped, and of a soft to semihard texture. The variety is rather early and of medium height. The straw is white but not very strong, as the wheat tends to bend and sometimes will lodge at maturity. Baart is a spring wheat, but is grown from fall sowing in California and Arizona.

The Baart variety has been sparingly grown in Australia for many years. It was introduced into the United States by the United States Department of Agriculture in 1900. Seed was distributed for experimental use in several parts of the country. The Arizona Agricultural Experiment Station received some and later distributed the variety in Arizona. From this distribution Baart became well established in that State by 1914. From Arizona the wheat spread to Washington, Idaho, and California. Considerable quantities of Baart were distributed in Oregon by the Sherman County and Harney County Branch Experiment Stations. It is now grown in all of the States west of the Great Plains area except possibly Utah and Wyoming. About 500,000 acres of Baart were grown in the United States in 1919 (Fig. 20). It is most important in Washington and California.

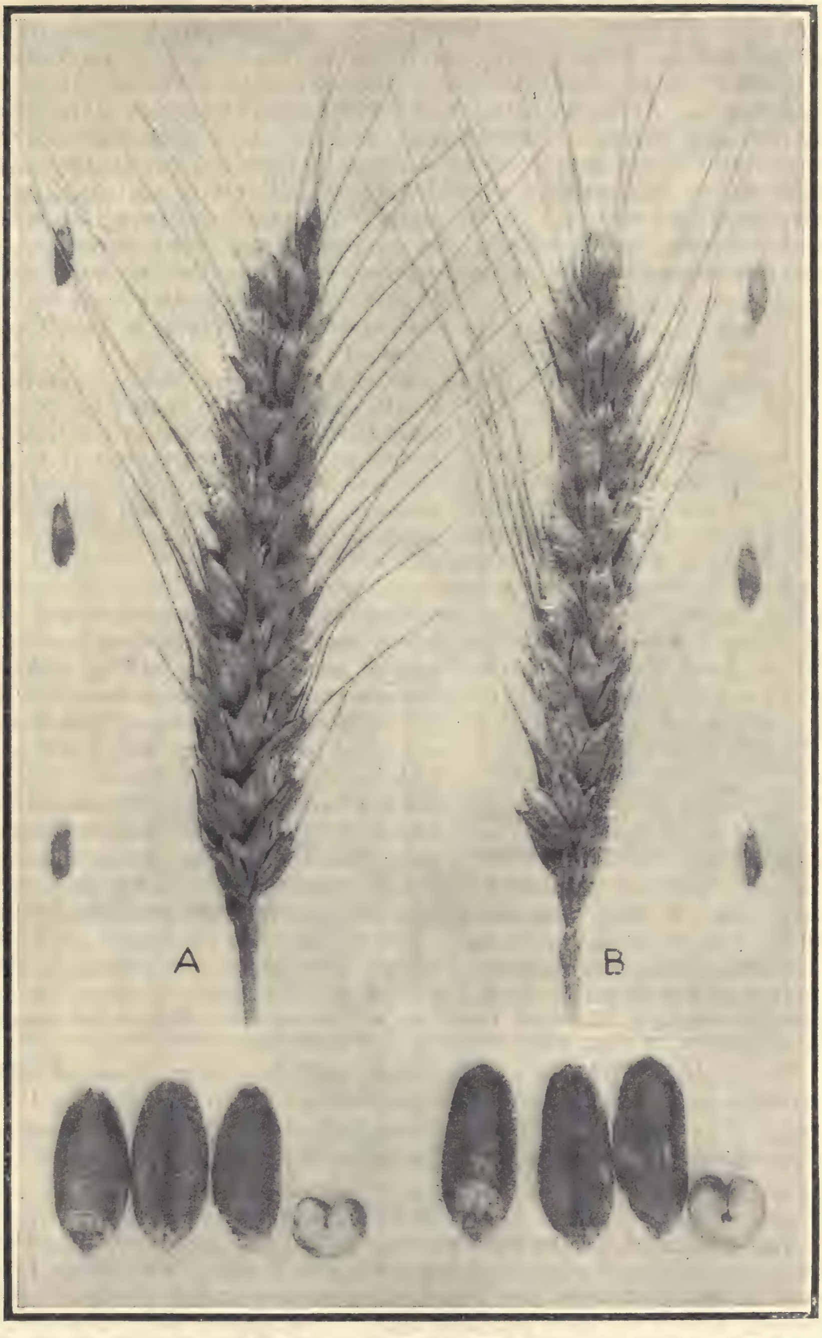

FIG. 19.—Heads, chaff, and kernels of Propo (*A*) and Baart (*B*) wheats. Heads and chaff, natural size; kernels, magnified 3 diameters.

Baart has shown excellent adaptation to the dry lands in the Pacific Northwest. Where the rainfall is less than 15 inches it has outyielded all other spring varieties in Washington. In eastern Oregon on dry lands it is outyielded as a spring variety by Hard Federation. At high altitudes in southeastern Oregon it is the highest yielding variety. Baart has given excellent yields in the Sacramento and lower San Joaquin Valleys in California. In those sections it has frequently outyielded Pacific Bluestem and has partly displaced that variety. On the irrigated lands of southern California and Arizona, Baart usually has outyielded all other varieties. It can not compete with Dicklow or Federation on the irrigated lands of southern Idaho and Oregon. It also is not satisfactory in humid sections.

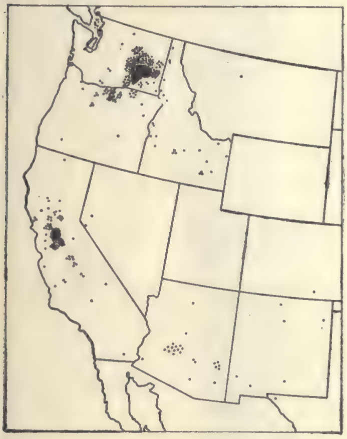

FIG. 20.—Outline map of the western United States, showing the distribution of Baart wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 500,500 acres.

In milling and baking qualities Baart is superior to most of the common white wheats, including Pacific Bluestem and Dicklow, but it is not equal to the best milling and baking varieties such as Bobs and Hard Federation.

PROPO.

The Propo (or Proper) wheat differs from Baart in having a faintly purple straw and in having smaller, softer, and whiter kernels (Fig. 19, *A*). Like Baart, it is a spring wheat, but it is grown from fall sowing in California.

Propo originated from some heads found in a field of wheat belonging to a Mr. Proper, in Sutter County, Calif., apparently during the early seventies. It was first known as Proper, but the spelling of the name soon became confused. The wheat was increased and distributed in the Sacramento Valley. Propo is now grown in that section and also in the coastal valleys of California. It is not an important variety, as less than 20,000 acres were reported grown in 1919.

The yields of Propo usually have been less than those of other varieties grown in the same section, such as Baart and Pacific Bluestem. The growing of Propo, therefore, should be discontinued, as it is not superior to these varieties in milling and baking qualities.

PALISADE.

The Palisade variety (known also as White Oregon, White Palisade, and White Spring) is quite similar to Propo. The straw, however, is white, slender, and weak. The variety is easily lodged. The kernels are of medium size and soft. It is grown only as a spring wheat.

The origin of Palisade is not known, but it has been grown in western Kansas and Nebraska for at least 15 or 20 years and was grown previously in the Central States. On the Kansas farms it is called White Oregon and White Spring.

This wheat is now grown in the elevated district comprising the adjoining portions of northeastern Colorado, southwestern Nebraska, and northwestern Kansas. With the exception of durum varieties, it is the most important spring wheat in that region. About 40,000 acres of this variety were grown in 1919.

Palisade has not given comparatively high yields in western Nebraska. In much of western Kansas it is a very poor variety. The section where Palisade is grown is best adapted to winter wheat. Spring wheat production is only supplementary to winter wheat, and it is a much poorer crop. From the limited information available it is believed that varieties of hard red spring and durum wheat will outyield Palisade. Palisade is a soft wheat of rather low milling and baking value, and much of the acreage should be replaced by winter varieties.

TALIMKA.

The Talimka (or Saumur) variety is strikingly different from any of the other common white wheats. The heads are open, with the meshes arranged in a zigzag fashion. The beards are short and stiff, but the beaks on the outer chaff are nearly as long as the beards. The kernels are very large, pointed, angular, extremely hard, and resemble those of durum wheat rather closely. It has a very weak straw.

Samples of this wheat have been introduced into this country by the United States Department of Agriculture, but it has not been distributed commercially. It occurs in the United States only as a mixture with Chul, which is identical with Talimka except in having red kernels. Chul mixed with Talimka is grown to a limited extent in California and Nevada.

Talimka usually does not give high comparative yields unless grown under exceptionally dry conditions. The straw is so weak and the crop so easily lodged that harvesting usually is difficult under favorable conditions. It does not produce flour suitable for bread making, so Talimka is of too little value to be grown.

Section 10.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), BROWN; WINTER WHEAT.

Only one variety of section 10 is commercially grown in the United States.

GENESEE GIANT.

Genesee Giant (Early Genesee Giant) is known also as Farmers Trust, Giant Squarehead, Pedigree Giant, Genesee, and Golden Cross. This wheat is easily distinguished by the erect, rather short, compact, clubbed, bearded heads having brown chaff. The kernels are short, broad, and soft to semihard, and those which are borne in the top or clubbed portion of the heads often are flattened or pinched like club wheats. It is grown only as a winter wheat.

Genesee Giant originated from composite crosses between several varieties made by A. N. Jones, of Newark, N. Y. The variety was first distributed in 1893. It was advertised and sold in the Eastern

States and apparently grown there, but at present it is grown commercially only in two counties in Utah. It is an unimportant variety.

In experiments Genesee Giant has not produced high yields in any part of the United States in comparison with the varieties commonly grown. The remaining acreage of this variety probably could be replaced profitably by other varieties. In milling and baking value Genesee Giant apparently is inferior to several of the common white wheats.

Section 11.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), BROWN; SPRING WHEATS.

The two commercial varieties in section 11 are grown to a limited extent.

SEVIER.

Sevier (Danish Hard) wheat has short, erect, square, compact heads, which are somewhat flattened on the sides like the club and durum wheats. The chaff is brown and the beards are of medium length. The kernels are rather large, usually hard and angular, and greatly resemble durum and poulard wheats except in having a longer brush. The plants are early and short and the straw is purple. In the appearance of the heads and kernels Sevier is almost intermediate between common and durum wheats. It also resembles poulard and club wheats in some characters. In milling and baking characteristics it resembles common wheat. Although a spring wheat, it shows a more or less intermediate habit of growth and remains prostrate on the ground for some time after sowing in the spring. As grown, Sevier contains mixtures of hairy chaff, red kernels, and some other variations.

The origin of Sevier is not known. It has been grown in Utah for 20 or 30 years. The wheat was observed in 1918 by George Stewart, of the Utah Agricultural Experiment Station, and later named Sevier. Prior to that time it was unknown outside of the district where it had been grown. The variety is now grown mostly on irrigated land in about four counties of central Utah, principally in Sevier County.

Sevier is grown on heavy irrigated lands because of its freedom from rust injury. It probably will not outyield Dicklow, however. It has shown fair yields on dry land, but being a spring wheat it can not compete with such varieties as Turkey, a hard red winter wheat. Owing to the mixture of red kernels in Sevier it must be classed as a mixed wheat and as such will have a lower market value. Sevier should not be grown except in the district in which it is now under cultivation, and there it probably should be largely replaced by Dicklow.

CANADIAN RED.

The Canadian Red (or Canadian Spring) variety differs from Sevier chiefly in having longer and more slender heads, shorter beaks, and white, instead of purple, straw. The plants are early and short, the straw slender and weak, and the beards rather stiff. The kernels are of medium size, rather hard, and slightly curved, but they do not resemble durum wheat. It is a true spring wheat.

Nothing is known concerning the origin of Canadian Red wheat, and the variety is not known to be grown in Canada. It was first obtained by the United States Department of Agriculture in 1919 from F. G. Stokes, of Kelseyville, Calif. It is grown to a limited extent in Lake County, Calif. Little is known concerning the yields and quality of this variety.

Section 12.—HEADS BEARDED; CHAFF VELVETY, WHITE; WINTER WHEAT.

Section 12 is distinct from the others containing bearded wheats, previously described, in having velvety or hairy chaff. Only one variety in this section is commercially grown, and it is of minor importance.

READ.

The Read (Read's Vermont Winter) wheat has bearded, compact, clubbed, inclined heads. The chaff is covered with short white hairs. The kernels are rather short, broad, and soft, and they are quite hairy at the tip. The plants are of medium height and about midseason in maturity. The straw is white, thick, and strong. It was developed and named by G. A. Read, of Charlotte, Vt., who states that it was originated in 1898 from a cross between Bearded Fife and a field selection, which occurred as a mixture in Bearded Fife and presumably Early Arcadian. It has been grown sparingly in Ashland County, Ohio, for more than seven years. The variety probably will not yield as well as several of the soft red winter varieties commonly grown in Ohio.

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This bulletin is a contribution from the

Bureau of Plant Industry	William A. Taylor, *Chief;*
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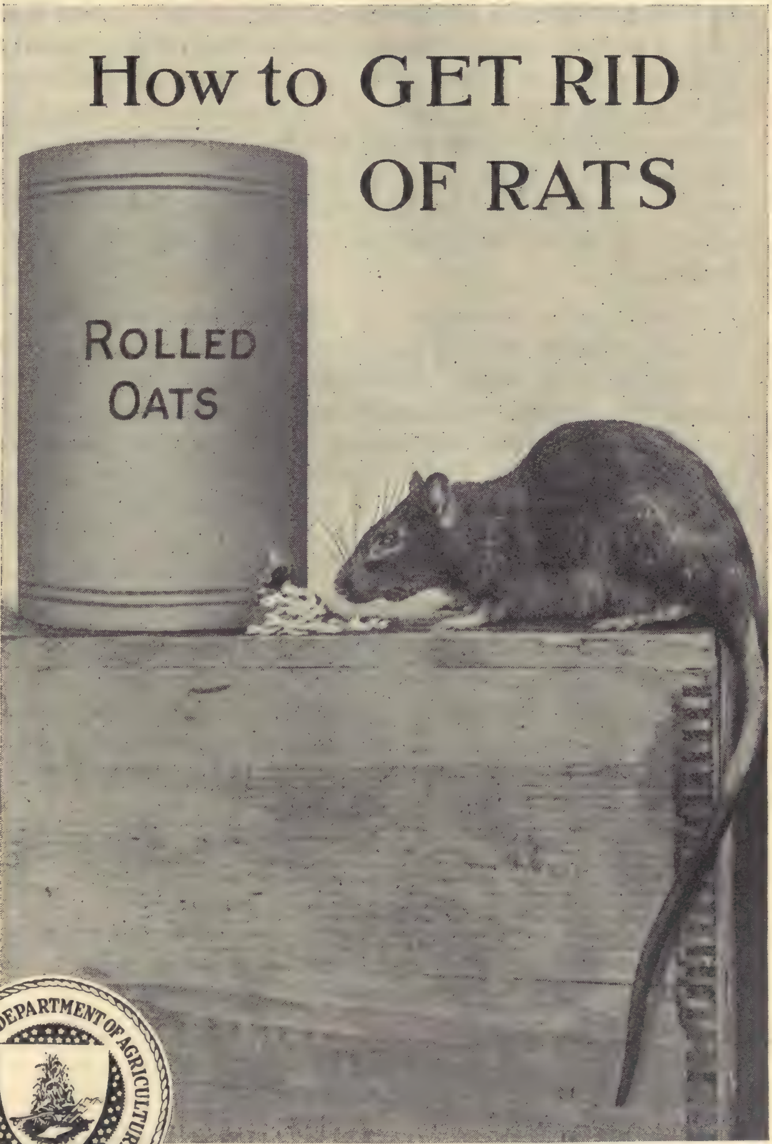
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1302

How to GET RID OF RATS



THE PROBLEM of how to get rid of rats is one that is usually approached with a feeling of uncertainty. Whether it arises from the first rat seen in the home or from the hordes of the pests that can no longer be endured on the farm or in the food-storage structure, the need of precise information on how to proceed is commonly felt. To describe definitely but briefly measures to be taken to be rid of rats is the purpose of this bulletin.

When left undisturbed in its chosen abode the rat increases with almost unbelievable rapidity and uses unceasingly its highly developed instincts at the ever-increasing expense of the housekeeper, farmer, or business establishment harboring it. Once rats have entrenched themselves, determined effort is necessary to eradicate them. The task is not a hopeless one, however, and effective measures persistently used will benefit not only the one-time supporter of the pests but also the community at large.

Individual effort is necessary to rat riddance, but community organization and united action are essential to insure permanent relief from the pests. Without cooperation there is always the prospect of reinfestation from adjacent property.

Washington, D. C. **Issued April, 1923**

HOW TO GET RID OF RATS.

By JAMES SILVER, *Biological Assistant, Division of Economic Investigations, Bureau of Biological Survey.*

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INTRODUCTION.

THE ENORMOUS demand for more efficient means of rat destruction provides a ready field for the exploitation of an endless variety of control methods. Advertisers and manufacturers of poisons, traps, and viruses, and of countless contrivances, flood our newspapers and magazines with an imposing array of plausible arguments and flattering testimonials, proclaiming their products as the best and only sure way to rat riddance. The result is that vast sums of money are literally thrown away on worthless substances and devices designed to outwit the wily rat. If the products were only half as effective as the salesmanship, the days of the rat would be numbered. This does not mean that all proprietary anti-rat products are without merit, but rather that extensive advertising does not always insure results satisfactory to the purchaser.

It has been found in the experience of investigators and demonstrators of the Biological Survey that a few simple measures consistently employed will rid a farm or a community of rats. Natural agencies unaided, such as cats, dogs, birds of prey, etc., can not be wholly relied upon to do the work for us. Control measures must be intelligently applied, and the results regularly noted. Rats are hard to exterminate, and regardless of the method employed success attends only close application and persistent effort. It is a case of man matching his wits against the highly developed instincts of the rat.

The large number of failures to exterminate rats is due in part to the use of inefficient methods, but half-hearted effort and easy discouragement are more often responsible. Rats can not long survive a concerted and sustained onslaught. They can be eliminated from any ordinary building or farm by the intelligent and judicious use of the methods here described.

The all-important measures to be taken are the removing of food and shelter from rats, poisoning and trapping them, and under certain conditions fumigating their burrows. These measures should be undertaken not only by individual effort but also through community cooperation.

ELIMINATING FOOD AND SHELTER.

Thorough cleanliness and orderliness discourage the presence of rats and constitute a strong incentive for them to seek other quarters. To eliminate food and hiding places entirely is to eliminate rats. This is not always possible, but the nearer the approach to this condition the more simple the rat-riddance problem becomes.

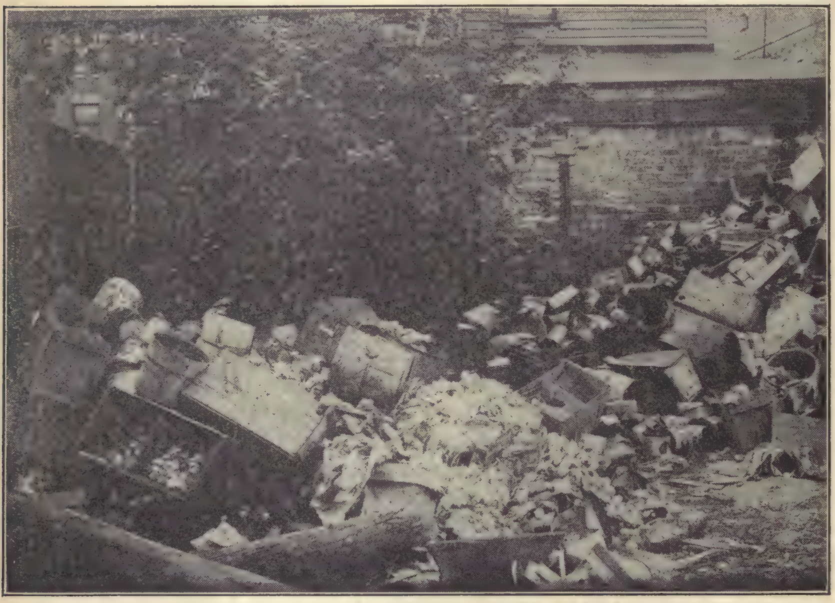

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FIG. 1.—Trash pile in rear of restaurant. Accumulations of this kind furnish food, shelter, and breeding places for rats. Such conditions should be controlled by suitable city ordinances and competent inspection.

The most important means of eliminating food and shelter are to store foodstuffs in rat-proof containers, to dispose of waste and garbage in tightly covered vessels, and to prevent the accumulation of trash, refuse, and other similar material (Fig. 1). Not only does lack of food and shelter reduce the breeding rate of rats, but increased hunger renders poisoning and trapping more effective.

POISONING.

The most efficient means known to the department for destroying rats is by poisoning, and poison is recommended for the purpose wherever it can be used with safety. Powdered barium carbonate is an inexpensive mineral, and seems best adapted for poisoning rats.[1] It is both odorless and tasteless, and baits containing it are readily taken by these pests (Fig. 2). It also has the advantage of being slow in its action, so that rats affected by it usually have time to leave the premises in search of water or to return to their burrows before they succumb.

The following directions for using barium carbonate have been carefully worked out and should be closely followed to obtain the best results.

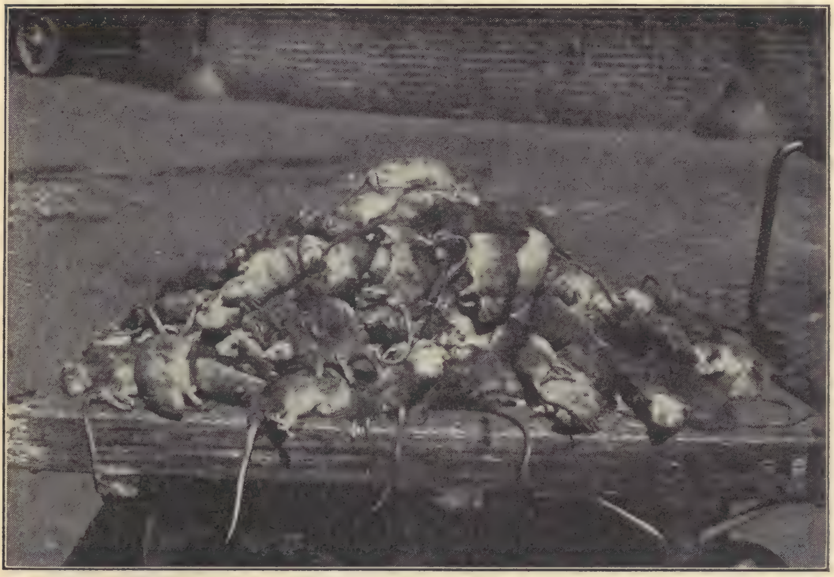

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FIG. 2.—The result of an over-night campaign in a public market. Barium carbonate baits, prepared and exposed in accordance with the instructions contained in this bulletin, were used.

KINDS OF BAIT.

A variety of baits used separately not only gives the rat a choice of foods but tends to make it less suspicious. One kind of each of the following classes of food mixed with barium carbonate is recommended:

(1) *Meat or other animal substance.*—Hamburg steak, sausage, fish, liver, bacon, or cheese.

(2) *Vegetables and fruits.*—Thin slices of muskmelon, apple, tomato, or cucumber; canned corn, or squash or pumpkin seed; or mashed banana, boiled carrot, or baked sweet potato.

(3) *Cereals.*—Rolled oats, bread, corn meal, flour, or cake. Kitchen scraps and garbage can be worked into the ration to advantage.

Baits should be fresh and preferably of good quality.

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[1] Other poisons commonly used are phosphorus, arsenic, and strychnine. Phosphorus is attended with danger from fire; arsenic is uncertain in its action; while strychnine is readily detected by rats and is too rapid in its action to make its use desirable in buildings. Barium carbonate has the advantage of being not only of proved effectiveness, but also inexpensive and relatively safe.

HOW TO PREPARE BAITS.

The powdered barium carbonate should be thoroughly mixed and worked into the soft baits in the proportion of 1 part of the mineral to 4 parts of the selected food. Add water when necessary to make the baits moist. Baits moistened to the consistency of soft mush are particularly acceptable to rats in dry weather.

Barium carbonate should be sifted over sliced baits and rubbed well into them with the fingers or a knife. The slices should be thin and should be moistened if necessary in order to attain as nearly as possible the 1 to 4 ratio. Soft baits may be mixed with the hands or with a spoon.

HOW TO DISTRIBUTE POISON.

A teaspoonful, or its equivalent, of each of the three or more kinds of baits prepared, should be exposed in places frequented by rats. In buildings baits should be set on strips of paper or boards where they may be easily removed.

A convenient and successful method of exposing baits is to place a teaspoonful in each of a number of small paper sacks and drop them in places accessible to rats or frequented by them. The sacks should be closed by twisting the top. Bait distributed in this manner serves to allay the suspicion of rats and will be taken by them more readily than if exposed in the open. It is better not to place the sacks near or at rat holes, but rather to scatter them promiscuously about. The sacks are usually carried into burrows or behind objects, where the contents are eaten in comfort and are more nearly consumed than in the open. In public places, where there is a possibility that the bait will be disturbed by people, the sacks should be labeled "POISON."

Baits of three or more kinds should be exposed in groups. Where rats are abundant baits may be exposed at intervals of 10 to 20 feet. Uneaten baits should be picked up the following morning and destroyed. If left exposed in warm places more than one day, baits will sour, and the resulting acid will gradually transform the barium into a bitter and highly objectionable form. Continue to distribute fresh baits in less quantity each night, repeating those that are eaten freely, and replacing those less relished, by others in the same class until the rats disappear or until no further baits are taken.

In stubborn cases it may become necessary to resort to prebaiting in order to dispose of old and cunning rats. This consists in exposing unpoisoned or fresh foods every night until rats take them freely, and then substituting the poisoned baits.

Poison used in poultry inclosures should be exposed in places inaccessible to chickens, as behind or under boxes, and it should be very wet or of such nature that the rats can not drag it from cover.

Caution.—Barium carbonate is a relatively mild poison, but the danger from accidents can not be over emphasized. *Keep it out of the reach of children and irresponsible persons and from domestic animals and fowls.*

Antidote.—Give an emetic consisting of either mustard or salt dissolved in warm water, or induce vomiting by inserting the finger in the back of the throat. Follow vomiting with a liberal dose of Epsom or Glauber salts.

TRAPPING.

Trapping rats, while equally as effective as poisoning, requires more skill and labor. It is recommended where the use of poison seems inadvisable.

Careful attention to detail is necessary in trapping rats, as the measure of success will depend largely upon the skill and resourcefulness with which the traps are handled.

While numbers of the more complicated traps and devices for catching rats are sometimes useful, the simple and inexpensive snap trap, sometimes called "guillotine," "spring," or "break back," has easily proved the most effective and consistent rat catcher (Fig. 3). There is little choice between the standard makes of this style of trap, and selection should be governed by strength and apparent durability. The essential is a trigger that will release the spring at a very light touch. The trigger should also be provided with a hook or other means of holding the bait fast. Large triggers have an advantage over small ones, as they have a greater surface for the rat to step on, and especially as they are better adapted for use along walls and narrow runways, where rats may be trapped successfully without baiting.

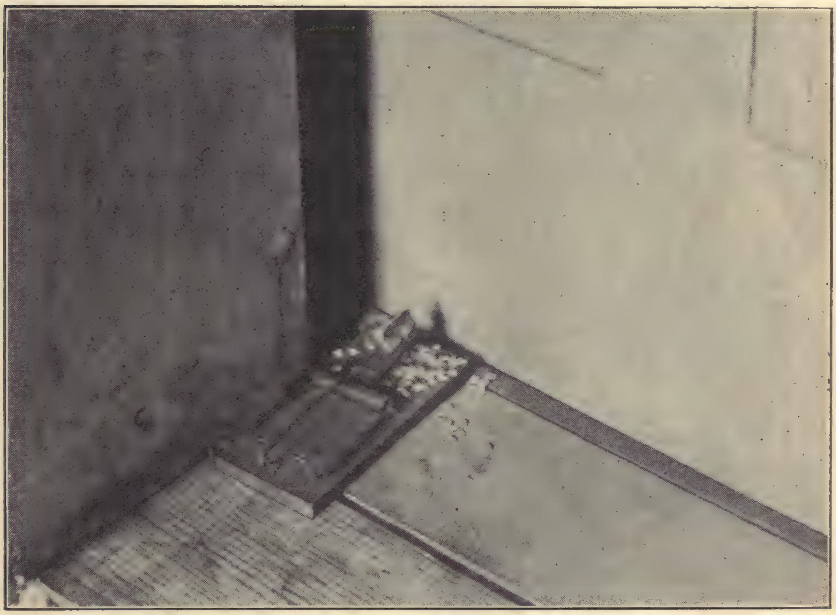
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FIG. 3.—An excellent type of trap properly set in a natural runway of the rat. In this instance the runway is back of a box placed a few inches away from the wall. When using such a runway the rat must pass over the trigger of the trap.

In trapping, as in poisoning, the kinds of baits used are of prime importance, and to give the rat a choice of foods and to lessen its suspicion the same principle of variety is equally applicable.

To get the best results the following directions for baiting and setting snap traps should be carefully observed.

KINDS OF BAIT.

Rolled oats, fried bacon, bread, and toasted cheese are the baits most frequently used. Baits which will easily adhere to the trigger hook, as fried bacon, raw or cooked meats, fish, nut meats, cheese, apples, or carrots, are recommended for general use. These may be made more attractive by sprinkling rolled oats or corn meal lightly over the trap. Almost any food suitable for human consumption will appeal to the gluttonous appetite of the rat, so that there should be no lack of variety.

WHERE TO SET TRAPS.

Rats rely on concealment for protection and avoid open spaces as much as possible. The best place to set traps, therefore, is close to walls, behind objects, in dark corners—anywhere that a rat in striving for concealment would run. Traps should be set in such a manner that the rat in following its natural course will pass directly over the trigger. For example, in setting along a wall the trap should extend from the wall at right angles, the trigger end close against it. Boards may be leaned against the wall, thus forming a natural runway for rats and a good setting place for traps.

HOW TO SET TRAPS.

Baits should be large and fastened securely to the trigger by means of the trigger hook or tied to the trigger with thread or fine wire, so that when attempting to remove them the rat will be sure to spring the trap (see Fig. 3). Traps should be set very lightly, so that they will spring easily.

After most of the rats have been caught, the others sometimes leave the premises. More often, however, the remaining rats are not frightened away, but avoid baits and prove very difficult to catch. Strategy must be used in outwitting such individuals. The most successful method is to camouflage the traps.

Traps set on the ground may be sunk slightly below the ground level. A small piece of paper or cloth should then be placed over the trigger end of the trap to prevent dirt from getting underneath and clogging the action, and the whole should be lightly covered with fine earth or sawdust.

The same method may be employed on hard floors, by burying the traps in a shallow pan of meal, sawdust, or grain. A trap set in this way may be placed in a runway without baiting, or several pieces of bait may be scattered over it. In stubborn cases, food may be exposed on pans of meal until the rats take it readily, when the traps should be set in the meal. Stones, boxes, or boards will often aid in directing an unsuspecting animal along an easy path over a trap.

GENERAL TRAPPING INSTRUCTIONS.

The presence of an abundance of food makes trapping much more difficult. Before starting a trapping campaign remove all accessible food and eliminate the sources of supply.

Plenty of traps should be used. Trying to catch a hundred rats with half a dozen traps will make those not caught suspicious and dishearten the trapper long before the job is completed. A dozen or more traps for a heavily infested dwelling and from 50 to 100 or more for farms and larger buildings are not too many. It is important that a sufficient number of traps be obtained to make the campaign short and decisive. The cost of traps is little compared with the loss occasioned by rats.

Traps should be kept in good working condition and should be carefully examined before setting to insure their instant operation. They should be kept reasonably clean, and if they become very foul, should be boiled and scraped. When trapping is done on a large scale, especially in damp places where metal parts of the traps may rust, an occasional dipping in melted paraffin will lengthen their usefulness, cause them to spring more easily, and have a deodorizing effect.

Trapping rats in larger buildings and on farms should be assigned to a man with a natural aptitude for such work. When interest is taken, only slight training is necessary for some men to become proficient in the work. Such men should be encouraged to persistent effort.

FUMIGANTS AND DETERRENTS.

CARBON BISULPHIDE.

In many places rat burrows may be fumigated with carbon bisulphide and the rats thus destroyed in the ground. This method is effective in fields, along ditch banks and levees, around farm buildings, and in dirt cellars, providing the burrow is dug in solid earth. The gas is more effective in heavy damp soils and in wet weather.

A wad of cotton or other absorbent material should be saturated with 1 ounce (2 tablespoonfuls) of carbon bisulphide and thrown or pushed as far as possible into each burrow; all burrow entrances should then be closed with moist earth to prevent the escape of the gas. A long pair of forceps is convenient for handling the absorbent material.

Caution.—*Carbon bisulphide is highly inflammable and explosive and should not be approached by fire.* It evaporates rapidly and should be kept in an air-tight container.

GASOLINE ENGINE EXHAUST.

Use of the exhaust of an automobile, tractor, or other gasoline engine in fumigating rat burrows is entirely practicable when there are only a small number of holes. The exhaust is directed into the rat burrow by means of a hose and the entrance around the hose is sealed with damp earth (Fig. 4). The carburetor is adjusted to obtain a rich mixture and the engine allowed to run at moderate speed for 10 minutes or more. This method may also be used successfully in destroying rats beneath floors or in other places where a concentration of the gas can be obtained.

NAPHTHALENE FLAKES.

In seed warehouses and similar structures where sacked grain is stored temporarily, or otherwise, it has been found that a liberal supply of flake naphthalene, scattered on the floor about the stacked grain and over the bags, is objectionable to rats and will keep them away. In the seed distribution work of the Bureau of Plant Industry of this department the need of a cheap repellent was felt because of the fact that the many tons of seeds sometimes on hand could not be placed in rat-proof rooms. Flake naphthalene was tried in 1912 and proved so satisfactory that it has been used continuously ever since. The flakes are scattered abundantly over bags of seed as they are stacked and also in bins and rooms containing filled packets. The naphthalene does not damage the seed in any way and can be used with impunity in any reasonably tight building. Because of its odor, the use of the naphthalene flakes is not recommended in places where food and feedstuffs are stored, unless the nature of the material is such that it can be thoroughly deodorized by airing before use.

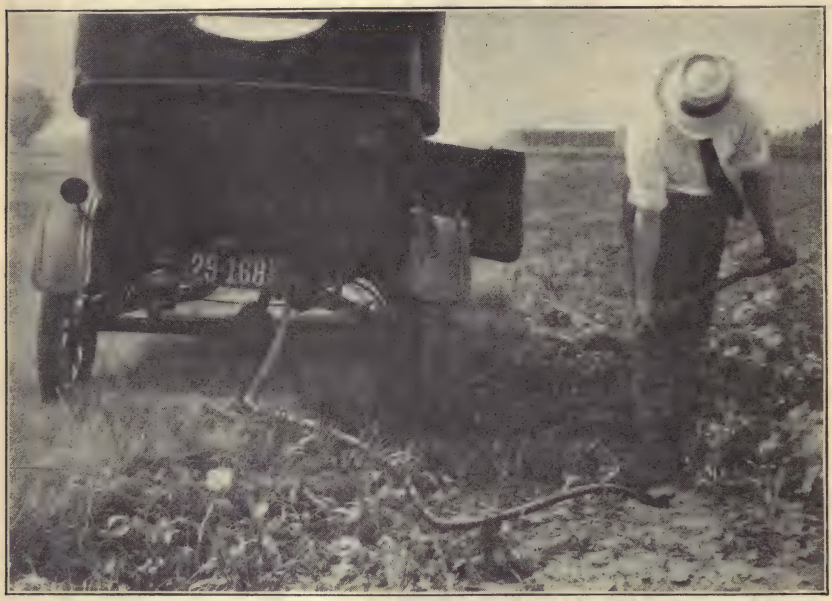

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FIG. 4.—Fumigating rat burrows by means of gasoline-engine exhaust.

RAT-PROOFING.

Poisoning, trapping, and other extermination methods carefully applied will give relief of more or less uncertain duration, but so long as there are rats in a neighborhood and they find it possible to get inside a building, there is always the danger of reinfestation. The only sure and final remedy for the rat nuisance is rat-proof construction. Without it, rats will get into a house, by gnawing if necessary, in order to locate an available and easily obtained food supply. The rat must be built out.

Most modern buildings and many older ones are so constructed as to be proof against the ingress of rats or could be made so at a relatively small cost. Owners of large warehouses, food depots, and other buildings where produce and other supplies are exposed to rat depredations have found that the cost of rat-proofing their buildings, even when the expense is considerable, is slight compared with the value of the resulting protection from loss, and that, in the long run, it is the cheapest rat insurance (Fig. 5). Rat-proofing of buildings, wherever it can be accomplished at reasonable expenditure, is recommended as the best and most permanent means of rat riddance.

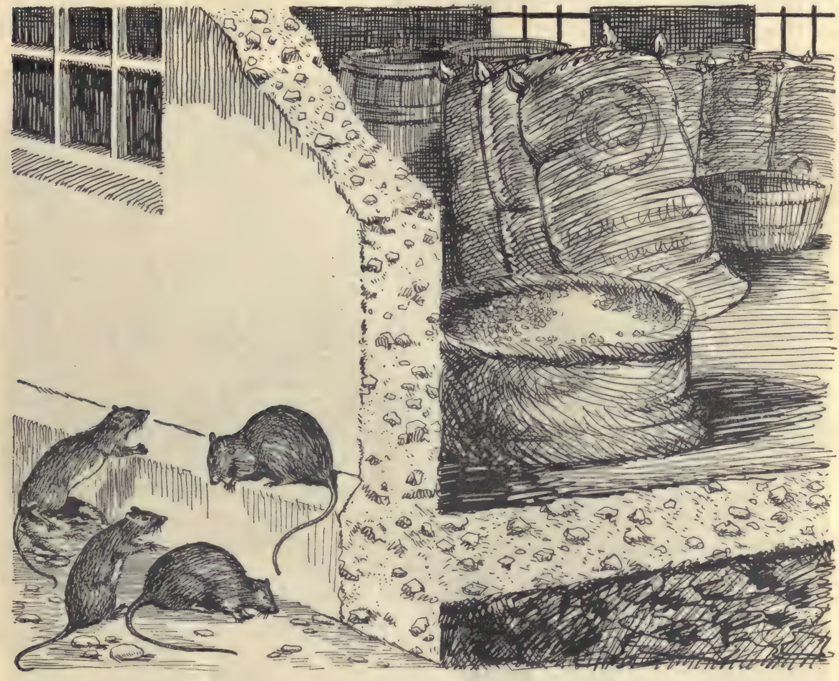

Fig. 5.—Build them out; the only sure and final way to rat riddance.

After having eliminated rats from a building by poisoning or trapping, reinfestation may often be prevented by closing with metal sheeting, or with concrete containing broken glass, all small openings that provide entrance for rats, and by screening basement windows and other large openings (Fig. 6). Rat-proofing should be planned for in the construction of all new buildings or in the remodeling of old ones. Building regulations, requiring that all structures be made rat-proof under competent inspection, would have a wholesome influence on future efforts at rat riddance.

Further information relative to rat-proof construction and repair and other measures looking toward permanent relief from the rat pest will be furnished on receipt of request addressed to the department.

NATURAL ENEMIES OF RATS.

Cats that are of real value as ratters are rare. Ferrets are valuable only when handled by experienced men aided by good dogs. The use of dogs in killing rats is recommended wherever practicable—small terriers, particularly when taught to hunt by themselves, are useful and sometimes will keep a farm free from rats.

While naturally burrowing rodents, rats do not ordinarily become excessively abundant in fields and woodland, because of their numerous natural enemies among the smaller predatory animals and birds of prey. If the relation of hawks and owls to rat infestation on the farm were better understood, the killing of such valuable birds would be confined to those actually caught preying upon poultry, and others would be left to their work of reducing the numbers of injurious rodents. (Fig. 7.) This policy would tend to lessen the number of the three[2] species of hawks and owls that live to any extent on poultry and birds, while the more than 40 beneficial species of predacious birds of these groups would be spared.

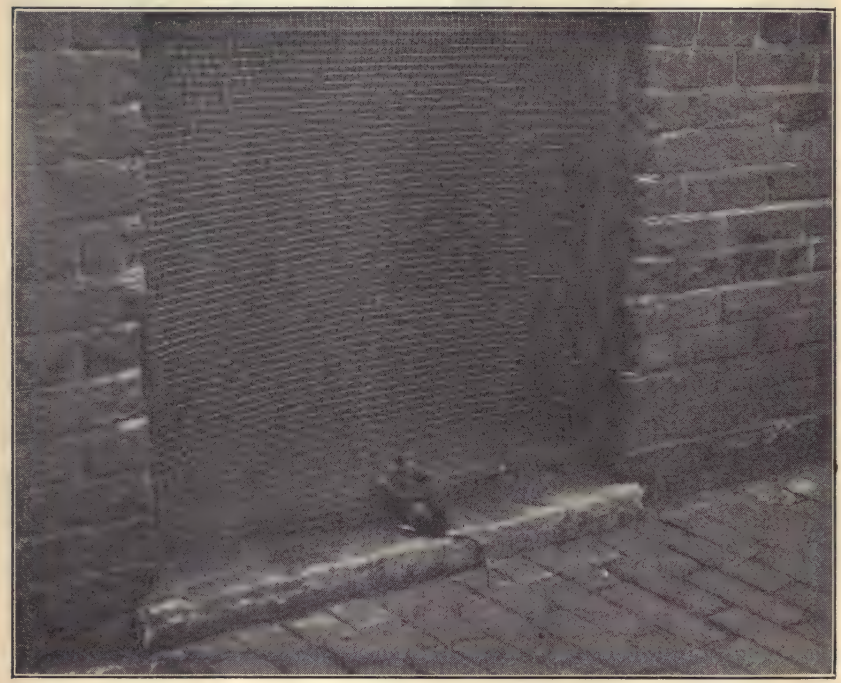

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FIG. 6.—Heavy wire screen of ¼-inch mesh will effectively close basement windows against rats.

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[2] These harmful hawks and owls are the Cooper hawk (*Accipiter cooperii*), the sharp-shinned hawk (*Accipiter velox*), and the great horned owl (*Bubo virginianus*). The duck hawk (*Rhynchodon peregrinus anatum*) and the goshawk (*Astur gentilis atricapillus*) are also classed as injurious but are too rare to be of consequence. The Cooper and sharp-shinned hawks destroy 90 per cent of the poultry and birds for which hawks and owls are responsible. The great horned owl is capable of great service in combating rats and other rodents and becomes a pest only where these are scarce and poultry runs at large. (See Fisher, A. K., "Hawks and Owls from the Standpoint of the Farmer": Biological Survey Circular No. 61, U. S. Dept. Agr., pp. 18, figs. 6, 1907.)

VIRUSES.

The control of rats by means of bacterial disease has a peculiar appeal that creates a ready market for the varied cultures already on the American market. This method, however, has proved generally unsatisfactory both in the experience of the Biological Survey and of other investigators and users, as gathered from reports from outside sources.

COMMUNITY COOPERATION.

When rats are known to hide and nest in large numbers in piles of lumber, sacked grain, hay or straw stacks, corn shocks, trash piles, and the like, an excellent means of destroying them is to inclose such places with a portable rat-proof fence, throw out the straw, lumber, or other material, and kill the rats with clubs or by the aid of dogs.

FIG. 7.—Twenty rat skulls were found in pellets taken from the nesting site of a pair of barn owls in Washington, D. C. Owls are an aid in warfare against the rat pest.

Rat hunts are often organized in rural communities, or rat-killing contests between rival teams, organizations, or communities are arranged, which result in large kills and furnish excellent sport to the participants.

Although the control of rats is largely an individual problem, rat infestation has a serious effect on the whole community, and organized effort is highly desirable. A man who allows rats to increase on his property until they menace the entire neighborhood, or a city dump which serves as an incubator for hordes of the pests, become matters of public concern. The elimination of rats from a whole community can best be accomplished only by the organized effort of all the citizens.

Organized anti-rat campaigns are increasing in popularity and are becoming the regular program not only in many municipalities and counties, but also in whole States. Such campaigns are of great value from economic, educational, and sanitary standpoints.

Assistance in planning, organizing, and prosecuting organized anti-rat campaigns will gladly be given by the Biological Survey in the form of direct aid whenever practicable, by an expert for campaigns of large scope, or by furnishing plans, general instructions, publicity material, and sample posters.[3]

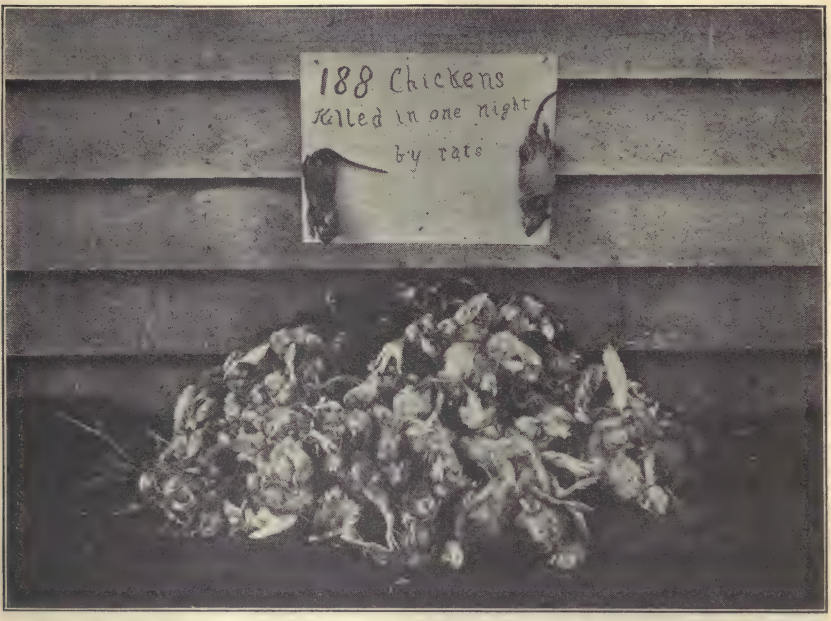

FIG. 8.—Taking the profits out of poultry raising. The rat is the most destructive animal in the world, and damage to poultry is a common cause of complaint against the pest.

SUMMARY.

Close all openings which provide entrance for rats, and screen basement windows in buildings that are otherwise rat proof.

Insure greater cleanliness; promptly dispose of garbage and eliminate piles of trash and refuse.

Poison with barium carbonate on farms and dumps, in farm structures, warehouses, and other buildings, and, where considered advisable, in dwellings.

Trap systematically with common snap traps when the use of poison is inexpedient.

Fumigate burrows and keep efficient rat dogs to assist in reducing the infestation on farms.

Organize cooperative rat hunts and plan a definite and determined campaign of rat riddance.

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[3] It is desirable, for the common good, that reports be sent to the Biological Survey, U. S. Department of Agriculture, of any marked success in efforts to be rid of rats, either by following the methods recommended in this bulletin or by employing others. If the methods here advocated do not prove successful, a statement of the facts in the case, describing the situation in detail, will be appreciated. Special attention will be given such cases with a view to overcoming the difficulties. Individual advice regarding rat riddance will be given when necessary.

Rats affect a larger percentage of the population than any other pest in existence. Infesting almost the entire world, they carry on unceasingly their work of destruction, of transmitting disease, and of inspiring repugnance or dread where they are present or threaten invasion of the home.

Damage by rats to produce and property in the United States amounts to about $200,000,000 annually. Injury to farm produce starts when the seed is first planted and continues through the growing season and harvest, in the wholesale and retail markets, and often in the home of the consumer. Such losses in the aggregate so affect the ultimate price of foodstuffs that everyone shares them, whether he maintains rats on his premises or not.

Modern ideas of thrift are opposed to such unnecessary waste, and the demand for relief is becoming insistent. What is most needed is a constant campaign of education to increase public intolerance of rats, carried on by extension and sanitation officials and all others interested. Individual efforts, which through the centuries have been ineffective in eliminating rats, must give way to organized endeavor.

For information regarding the relation of the rat to the public health, address the Surgeon General, United States Public Health Service, Washington, D. C. For information relative to the habits, life history, and economic status of the rat and for additional information in regard to anti-rat campaigns and methods of control, address the Bureau of Biological Survey, United States Department of Agriculture, Washington, D. C.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No 1303

The CLUB WHEATS

THE CLUB WHEATS differ from other classes of wheat in having short, compact heads and small kernels. They are grown almost exclusively in the region west of the Rocky Mountains and are most important in Washington, California, and Oregon. They are best adapted to the subhumid and irrigated sections within these States. About 1,000,000 acres of club wheat are grown annually in the United States, which is less than 2 per cent of the total wheat acreage.

Owing to its soft texture and low protein content club wheat is not well adapted for bread making, but is used in the making of pastry flour or is exported.

There are 14 distinct varieties of club wheat commercially grown. They have either white or red kernels and are grown from both fall and spring sowing. The older varieties are of Chilean origin. Five of the newer varieties are of hybrid origin, resulting from crosses between Little Club and common wheats.

Hybrid 128 is the leading variety of club wheat. It is a white-kerneled winter wheat and is best adapted to the subhumid sections of eastern Washington, Oregon, and northern Idaho. It is very productive, but is of low milling value and also is very susceptible to smut.

Jenkin is the best yielding variety in the humid sections and under irrigation. It is a white-kerneled spring wheat, but is grown from both fall and spring sowing in eastern Washington and northern Idaho.

Hybrid 123 is the most important and productive red-kerneled variety of club wheat and can be grown from both fall and spring sowing. Coppei is a productive red-kerneled variety, grown principally from fall sowing.

Hybrid 143 is a white-kerneled variety that is grown from both fall and spring sowing. Little Club, Big Club, Redchaff, and several other white-kerneled spring wheats were formerly important, but are now being replaced by more productive varieties.

Washington, D. C. January, 1923

THE CLUB WHEATS.[1]

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WHAT ARE CLUB WHEATS?

THE CLUB WHEATS have short, thick, and very compact heads and small kernels. Because of these distinctive characters, they usually are placed in a different division or so-called subspecies (*Triticum sativum compactum*) from the common bread wheats (*Triticum sativum vulgare*). Over a million acres, or about 1.7 per cent of the wheat acreage of the United States, are devoted annually to the production of club wheat. There are 14 distinct varieties commercially grown. They have either red or white kernels and are grown from both spring and fall sowing. The grain of most of the varieties is soft and inferior to other classes of American wheats for milling and bread making. Under the Official Grain Standards of the United States the white-kerneled varieties are graded in the subclass (*c*) Western White of the Class (V) White Wheat, and the red-kerneled varieties in the subclass (*b*) Western Red of the Class (IV) Soft Red Winter Wheat.

WHERE GROWN.

The States leading in the production of club wheat are Washington, California, Oregon, and Idaho. A smaller acreage is grown also in Utah and New Mexico. Only limited quantities are grown east of the Rocky Mountains, and none, as far as known, east of the western Great Plains area. In these Western States the club wheats are grown principally in the subhumid and irrigated sections. The distribution of club wheat in the United States in 1919 is shown on the map (Fig. 1).

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[1] The information given in this bulletin is based upon (1) varietal experiments conducted by the Office of Cereal Investigations of the Bureau of Plant Industry, United States Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) a survey of the wheat varieties of the United States, in cooperation with the then Bureau of Crop Estimates, based upon about 19,000 returns from 70,000 questionnaires sent to crop correspondents; (4) several years of personal observations by the writers in the wheat fields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Milling-Investigations Section of the Bureau of Agricultural Economics in cooperation with the Office of Cereal Investigations.

AREAS TO WHICH ADAPTED.

The club wheats are best adapted to the intermountain sections of the Pacific Coast States where they are now largely grown. This area is characterized by rather mild, rainy winters and hot, dry summers. Club wheat can not be grown with success in regions where rainy or humid weather prevails at ripening time, or where stem rust is of common occurrence, or as winter wheat in sections having severe winters. Club wheats therefore should not be grown in the Great Plains area or in the eastern United States.

In the intermountain sections of the Pacific States club wheats are well adapted, partly because the chaff and heads are firm or tough and shattering seldom occurs in spite of the hot, dry, windy weather. For this reason the club wheats are well adapted to harvesting with the header or combined harvester, where the wheat often is allowed to stand for several weeks after it is ripe before being harvested. The stems of the club wheat also are strong and stiff, so the wheat rarely lodges or breaks over. The meshes (spikelets) of the short, thick heads contain from three to eight kernels and are closely crowded. Owing to this compactness many of the kernels are lopsided or pinched. They also are usually soft and starchy, partly owing to yellow berry. The club wheats under favorable conditions are of medium height or tall, although under dry conditions the plants may be short. In general, these wheats are nearly as tall as and some are taller than the common wheats.

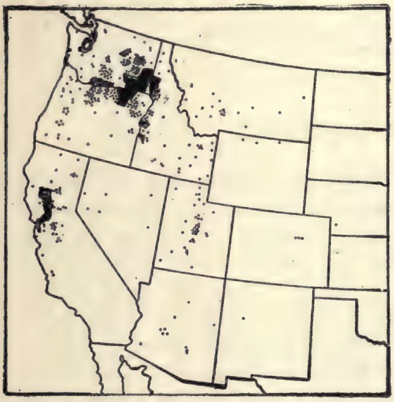

FIG. 1.—Outline map of the United States, showing where club wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 1,133,700 acres.

Not all so-called club wheats are true club varieties. Varieties of common wheat having clavate, or club-shaped, heads (widest at the tip) are sometimes, but wrongly, called club wheats. The heads of most varieties of true club wheat are not club shaped, but are more or less oblong, that is, as wide at the bottom as at the top.

The Surprise variety (known also as California Club, California Gem, Golden Gate Club, Imperial Club, Silver Club, or Smith Club) and the Dicklow are white-kerneled common wheats having a clavate, or club-shaped, head, but should not be confused with the true club wheats. Red Russian, sometimes known as Australian Club, also is a common wheat of the soft red winter class. The wheat known in the Southeastern States as Club, Club Head, Double Head, Stub Head, and by numerous other names is not a club wheat, but is the Fultzo-Mediterranean, a variety of soft red winter common wheat. The Sonora variety was formerly classed as White Club in the Federal Grain Standards because in kernel quality it is similar to the club varieties, but it is a common wheat and very different from the club wheats in many characters.

Owing to the soft texture of the kernels of most of the club varieties and the fact that club wheat is mostly grown in sections producing wheat of low protein content, the grain of this class of wheat is not well suited for the production of bread-making flour. Much of the club wheat grown in the United States is exported, and the remainder is used largely in the making of pastry flour and blending with flour of other classes of wheat for bread making.

VARIETIES.

The older varieties of club wheat grown in the United States are of Chilean origin. They were imported from Chile into California and Oregon during the period from 1850 to 1870, when these States were being settled and developed. Several cargoes of club wheat were received and used for seed in both of the above States during this period.

From these early varieties have come several new varieties of club wheat. Some have been developed from mixtures found in fields. In the regions where club wheats are grown, natural cross-fertilization in wheat is of frequent occurrence. It is quite probable that some of the new types of club wheat have arisen from natural crossing with varieties of common wheat.

No less than five varieties of club wheat now grown commercially were developed by artificial hybridization at the Washington Agricultural Experiment Station. These wheats are the result of crosses made by Prof. W. J. Spillman between the Little Club variety of club wheat and different varieties of common wheat. Because they retain the characteristics of club wheat they are still classed as such.

For convenience of discussion the club wheats are divided into seven sections, on the basis of head and kernel characters.

DISTINGUISHING CHARACTERS AND VARIETIES.

SECTION 1.—Heads beardless; chaff glabrous (not velvety), white or yellow; kernels white.
Little Club, Big Club, Hybrid 128, Hybrid 143, Hybrid 63.
SECTION 2.—Heads beardless; chaff glabrous (not velvety), white or yellow; kernels red.
Hybrid 123, Hybrid 108.
SECTION 3.—Heads beardless; chaff glabrous (not velvety), brown or red; kernels white.
Jenkin, Redchaff, Bluechaff.
SECTION 4.—Heads beardless; chaff glabrous (not velvety), brown or red; kernels red.
Dale.
SECTION 5.—Heads beardless; chaff velvety, white or yellow; kernels red.
Coppei.
SECTION 6.—Heads beardless; chaff velvety, brown or red; kernels white.
Wilbur.
SECTION 7.—Heads bearded; chaff glabrous (not velvety), brown or red; kernels red.
Mayview.

SECTION I.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW; KERNELS WHITE.

The most important club varieties are included in this section. Of the five varieties four are spring wheats and one is a winter wheat.

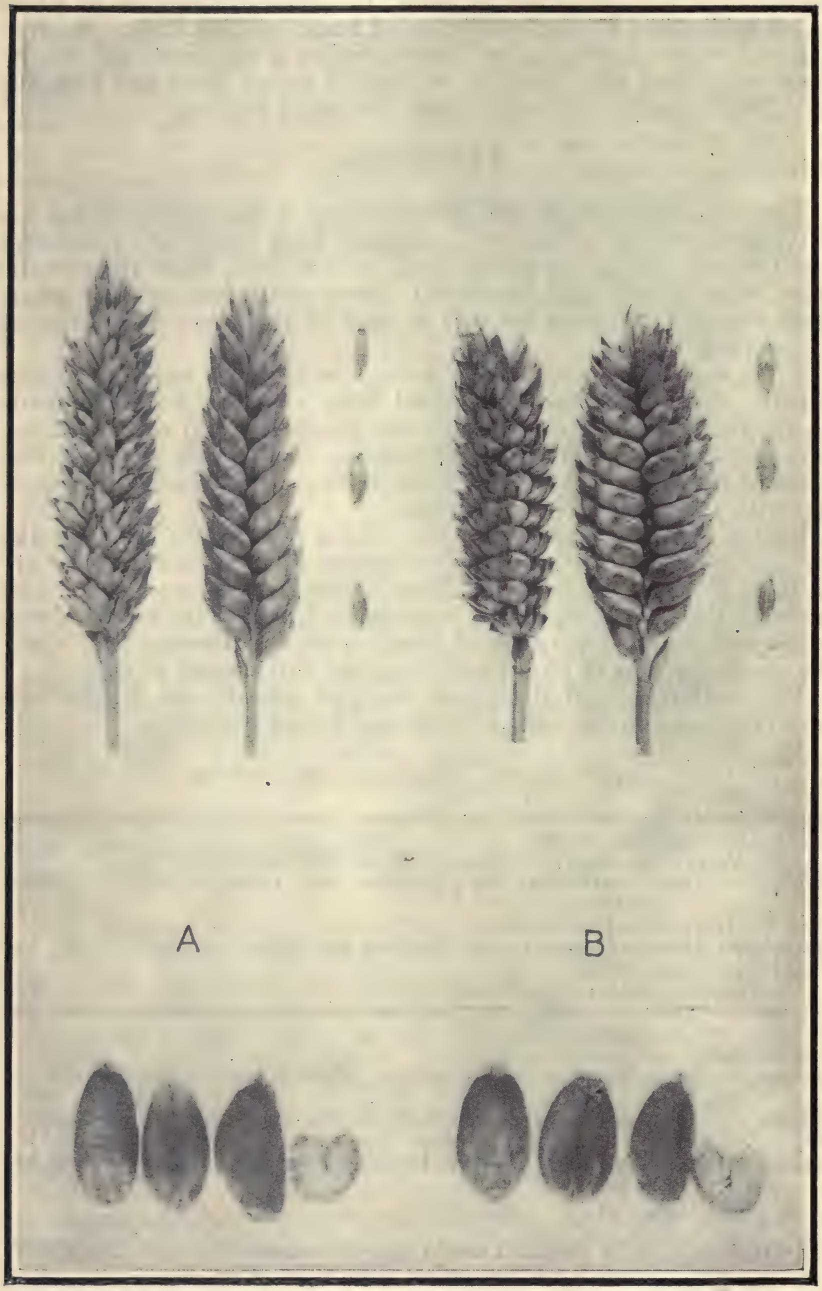

FIG. 2.—Heads, chaff, and kernels of Little Club (A) and Big Club (B). Heads and chaff, natural size; kernels, magnified 3 diameters.

LITTLE CLUB.

The Little Club (or Small Club) is a spring wheat, but it is grown often from fall sowing. It has longer and more slender heads and kernels than the other club varieties. The heads of Little Club usually are 2 to 2½ inches long and are oblong in shape (Fig. 2, *A*). The plants are tall, erect, and late.

The origin of Little Club wheat is not definitely known, but it is believed to have been introduced from Chile. It probably was one of the first varieties of wheat grown in the Columbia Basin section of Oregon and also probably was grown in California at an early date. It was reported grown in Yolo County, Calif., as early as 1878. Little Club was formerly the leading variety of wheat in eastern Oregon and Washington, but in recent years it has been largely replaced by more productive varieties.

The Little Club wheat is grown in all States west of the Rocky Mountains, but principally in the Sacramento Valley of California, in northeastern Oregon, eastern Washington, and western Idaho. It was estimated that more than 100,000 acres of Little Club wheat were grown in 1919. The distribution of Little Club is shown on the map (Fig. 3).

Little Club gives good yields under favorable conditions, but it is not well suited to districts of very limited rainfall. It is well adapted for growing under irrigation. Because of its tall straight straw this variety is sometimes sown around the border or right-of-way of fields of bearded wheat, to be cut for hay. The borders are removed to permit the passage of large harvesting machines. In general, the Little Club wheat could be advantageously replaced by other varieties of club or common wheats. Several varieties of common white wheat will outyield Little Club when fall sown in the Sacramento Valley of California and also when spring sown in Oregon and Washington. In the latter States some true winter wheats usually give higher yields than Little Club from fall sowing. Among these is Hybrid 128, a club wheat.

Like most club varieties, Little Club is of poor milling and bread-making quality as compared with other classes of wheat. It is equal or superior, however, to other varieties of club wheat in milling and baking value.

BIG CLUB.

The Big Club variety (known also as Big Four, Chile Club, Crookneck Club, Montezuma Club, and Salt Lake Club) differs from Little Club in having wider, shorter, and thicker heads and wider and rounded kernels (Fig. 2, *B*). Its chief distinction is the presence of curves and crooks in the stem immediately below the head. The variety is often called Crookneck Club because of this character. In spite of the curves in the stems, the heads of Big Club wheat are erect or nearly so.

Big Club is reported to have been introduced into Oregon from Chile about 1870. It was grown in California as early as 1866, however. The variety was first known as Chile Club and Oregon Club. It was formerly widely grown in the Pacific Coast States, but is now of only minor importance.

Big Club is still grown in scattered areas in California, Idaho, Montana, Oregon, Utah, and Washington. This distribution is shown on the map (Fig. 4).

The yields of Big Club usually have been less than those of Little Club and most other varieties in practically all sections where it is grown. This wheat probably should be dropped from cultivation. Very little is known concerning the milling and baking value of Big Club except that it is not generally considered any better than other varieties of club wheat.

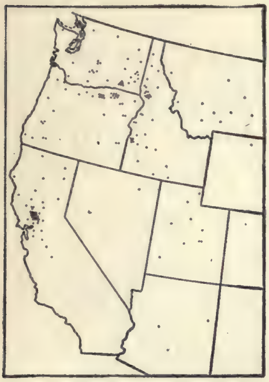

FIG. 3.—Outline map of a portion of the western United States, showing the distribution of Little Club wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 106,100 acres.

HYBRID 128.

The Hybrid 128 (Washington Hybrid No. 128) variety is a winter wheat and can not be successfully grown for spring sowing. The heads of this variety can scarcely be distinguished from those of the Big Club (Fig. 5, *A*). The kernels of the two varieties also are quite similar, except that those of Hybrid 128 are more pinched and irregular in shape. The plants of Hybrid 128 are of medium height. This variety is very susceptible to bunt or stinking smut and often is considerably injured by this disease.

Hybrid 128 was originated at the Washington Agricultural Experiment Station from a cross between Jones Fife (a soft red winter wheat) and Little Club. The cross was made in 1899 by Prof. W. J. Spillman. After selecting and testing for eight years, this new winter club wheat was distributed to farmers by the Washington station. It has since become the most important variety of club wheat.

Hybrid 128 is grown almost entirely in the southeastern portion of Washington and adjoining districts in Idaho and Oregon. It is of most importance in Walla Walla and Whitman Counties, Wash., and in Umatilla County, Oreg. It was estimated that more than 250,000 acres of this variety were grown in 1919, and since that time its acreage has considerably increased. The distribution of Hybrid 128 in 1919 is shown on the map (Fig. 6).

Hybrid 128 is perhaps the highest yielding variety of wheat in the section where it is now extensively grown. Its production as a winter wheat is limited only by its injury from smut and its low market value. In spite of these handicaps it is a very profitable variety. Outside of the sections of Washington, Idaho, and Oregon where it is now grown, and a short distance beyond these sections, Hybrid 128 is not especially promising. Until it can be replaced with an equally productive variety of higher quality

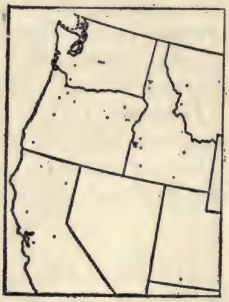

FIG. 4.—Outline map of a portion of the United States, showing the distribution of Big Club wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area 21,700 acres.

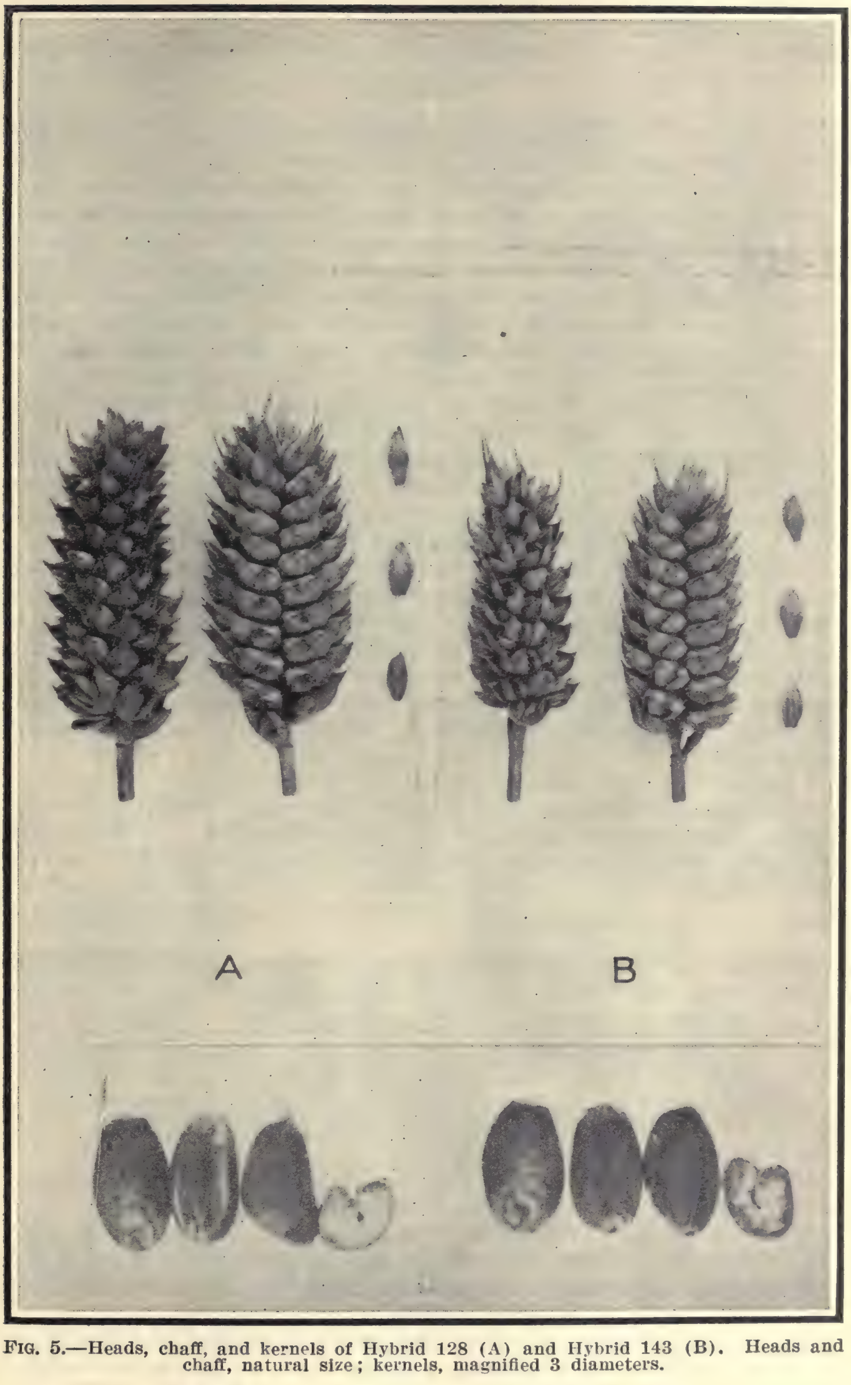

FIG. 5.—Heads, chaff, and kernels of Hybrid 128 (A) and Hybrid 143 (B). Heads and chaff, natural size; kernels, magnified 3 diameters.

and smut resistance, Hybrid 128 should continue to be an important wheat.

Hybrid 128 is a poor wheat for bread making and perhaps is inferior in this respect to nearly all of the white-kerneled club wheats.

HYBRID 143.

The Hybrid 143 (Shot Club) variety has very short, blunt, and blocky heads, and small, short, white kernels (Fig. 5, *B*). It is a spring wheat, but is more or less intermediate in its habit of growth and is grown from both fall and spring sowing. When sown late in the spring this variety spreads out on the ground like a winter wheat; heading and ripening, therefore, are somewhat delayed and yields are comparatively poor. The plants are of medium height.

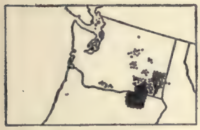

FIG. 6.—Outline map of a portion of the United States, showing the distribution of Hybrid 128 wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 259,900 acres.

Hybrid 143 also was originated at the Washington Agricultural Experiment Station. It is the result of a cross made in 1899 between Little Club and White Track, the latter a common white winter wheat. Hybrid 143 was distributed by the Washington station in 1907.

Hybrid 143 is grown in several counties in southeastern Washington. About 50,000 acres of the variety were grown in that State in 1919 (Fig. 7). The yields of Hybrid 143 usually are not as large as those of other varieties, being outyielded by Hybrid 128 when fall sown and by Jenkin, Little Club, and Redchaff as well as by several common varieties when sown in the spring. Hybrid 143 could be profitably replaced by more productive varieties of better quality.

The milling and baking quality of Hybrid 143 is superior to that of Hybrid 128 and Jenkin, but inferior to that of Little Club. It also is inferior to most varieties of common white wheat.

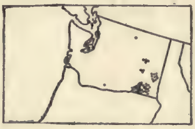

FIG. 7.—Outline map of a portion of the United States showing the distribution of Hybrid 143 wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 49,500 acres.

HYBRID 63.

Hybrid 63, sometimes called Turkey Hybrid, differs from the other wheats of this section in having harder kernels. The heads of Hybrid 63 resemble those of Hybrid 143 in shape, but the outer chaff (glumes) of each mesh is longer and narrower. Hybrid 63 is a spring wheat, although it usually is fall sown. The plants are of medium height.

Hybrid 63 was produced at the Washington Agricultural Experiment Station by crossing Little Club and Turkey, the latter a hard red winter wheat. This wheat was distributed to farmers in 1907.

The Hybrid 63 wheat is grown in several counties in Washington and Oregon. It is not an important variety in either State. Less than 40,000 acres are grown annually.

Hybrid 63 is not as hardy as true winter varieties and should be replaced by Hybrid 128 or better adapted varieties of common winter wheat. As a spring wheat it also is a poorer yielding variety than Jenkin and several common white wheats. It is best adapted to districts having a rainfall of 15 to 18 inches. Although the kernel is somewhat harder than that of most other club varieties, limited milling and baking experiments indicate it is not of higher quality.

SECTION 2.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW; KERNELS RED.

In this section are two red-kerneled varieties produced by hybridization at the Washington Agricultural Experiment Station. These wheats usually are designated commercially as Red Hybrid and Red Walla and graded in the subclass (*b*) Western Red under the Official Grain Standards. Both varieties originated from crosses between Little Club and Jones Fife made in 1899. Both varieties are spring wheats and have rather short beardless heads with glabrous white chaff and small red kernels.

HYBRID 123.

Hybrid 123 (known also as Red Hybrid and Red Walla) possesses the characteristics mentioned above. The kernels when free from yellow berry are semihard, but as commonly grown they usually appear quite starchy. Hybrid 123 was first distributed in 1907 from the Washington Agricultural Experiment Station. About 28,000 acres of this variety were grown in eastern Washington and eastern Oregon in 1919. It is a high-yielding wheat, and in some sections outyields Hybrid 128. In milling and baking quality Hybrid 123 is superior to Hybrid 128 and also to Red Russian and Jones Fife, soft red winter common wheats, although its market price is less than Jones Fife.

HYBRID 108.

Hybrid 108 differs from Hybrid 123 in having shorter heads and softer kernels. Its origin and history are the same as these of Hybrid 123. In 1919 Hybrid 108 was reported only in Whitman County, Wash. This variety has not been satisfactory in either yield or quality and should be entirely discontinued.

SECTION 3.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED; KERNELS WHITE.

The club wheats of this section include three varieties having erect beardless heads, reddish chaff, and soft white kernels. These wheats are tall and have midsized to large heads for club varieties and strong stems. In general, they are adapted to districts having an annual precipitation of more than 15 inches.

JENKIN.

The Jenkin (Jenkin's Club) wheat is the leading variety discussed in this section. It is somewhat similar to Little Club, except in having brown or red chaff and shorter, wider kernels (Fig. 8, *A*). The heads are about 2 inches long and oblong in shape. The plants are very tall and late, being taller than most of the common wheats grown in the United States. It is a spring wheat, but is often fall sown.

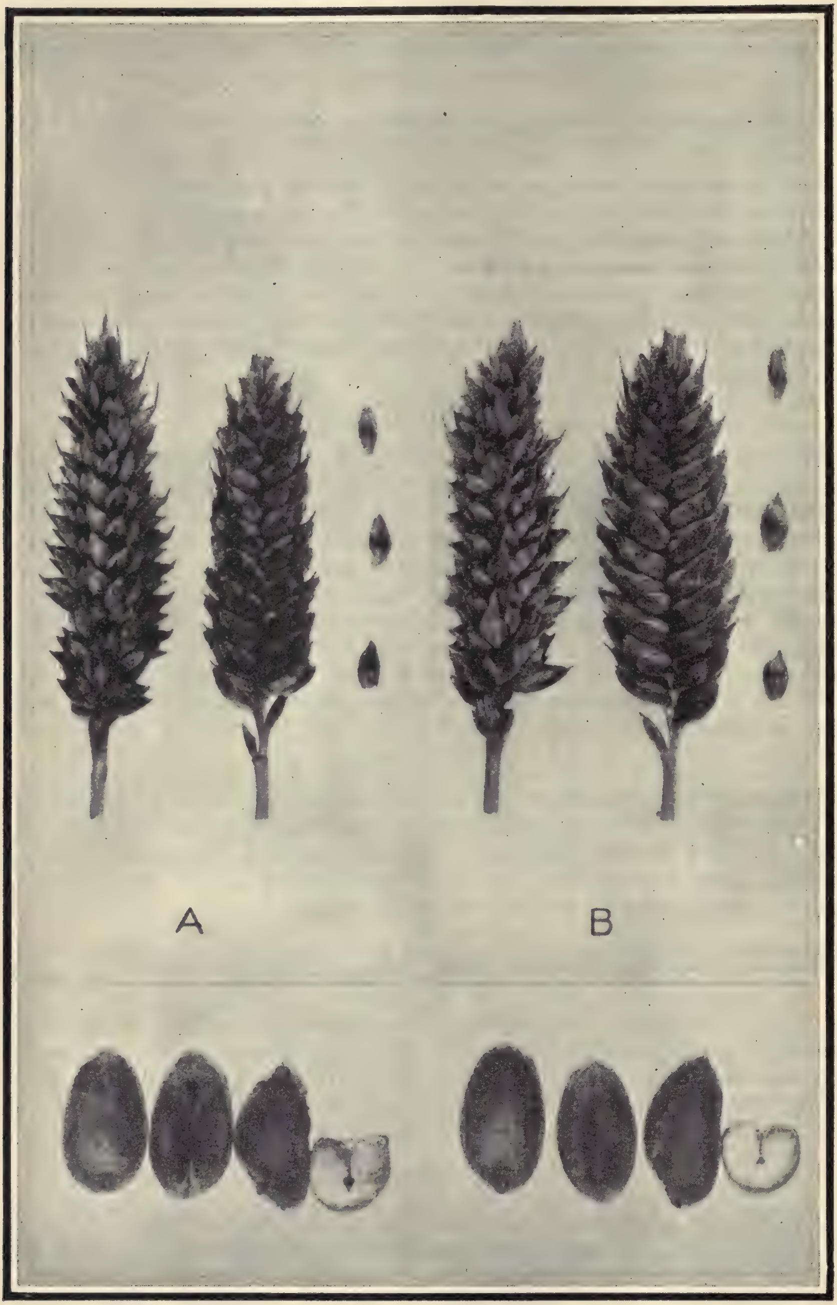

FIG. 8.—Heads, chaff, and kernels of Jenkin (A) and Redchaff (B). Heads and chaff, natural size; kernels, magnified 3 diameters.

The origin of Jenkin is not known. It has been grown in eastern Washington at least since 1895 and since 1900 in the Walla Walla Valley of Washington and in Umatilla County, Oreg., where it is still an important variety. In this and adjacent districts of southeastern Washington and northeastern Oregon it is grown rather extensively from both fall and spring sowing. About 66,000 acres were reported in 1919. The distribution of this acreage is shown on the map (Fig. 9).

The Jenkin variety is adapted to irrigated lands and to the subhumid and cooler sections of southeastern Washington and northwestern Idaho. It is a high-yielding wheat under these conditions when either fall or spring sown. Under less favorable conditions it should be replaced as a winter wheat by Hybrid 128 or Turkey, a hard red winter common wheat. Because of its late maturity it is easily injured by frost, drought, or hot winds, which often occur when it is spring sown. Jenkin should continue to be an important wheat in the sections where it is adapted. Because of its tall, rank growth, it is an excellent hay wheat and is often grown as such, especially around the borders of fields of bearded wheats.

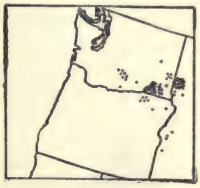

FIG. 9.—Outline map of a portion of the United States, showing the distribution of Jenkin wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 66,500 acres.

The milling and baking qualities of Jenkin are but slightly better than those of Hybrid 128.

REDCHAFF.

The Redchaff (Red Chaff or Oregon Red Chaff) wheat differs from Jenkin in being shorter and earlier and in having more club-shaped heads and a lighter brown chaff (Fig. 8, *B*). Although a spring wheat, Redchaff often is fall sown. It is rather tall and late. The chaff is a pale-brown color.

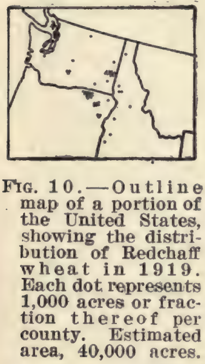

FIG. 10.—Outline map of a portion of the United States, showing the distribution of Redchaff wheat in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 40,000 acres.

The origin of Redchaff is undetermined. It has been an important variety in portions of the Columbia Basin of Oregon and Washington since 1907, and perhaps for many years earlier.

Redchaff is not as extensively grown as Jenkin, but it is of considerable importance along the foothills of the Blue Mountains of Oregon. It also is grown in Whitman County, Wash., and to a small extent in other districts of eastern Washington and western Idaho. About 40,000 acres of the variety were reported in 1919. The distribution of this acreage is shown in Figure 10.

The Redchaff is adapted to about the same conditions as Jenkin, but being slightly shorter and earlier, can be more successfully grown in slightly drier localities or on poorer soils. In comparative experiments the Redchaff has not given very high yields and the growing of this variety probably should be restricted to the portions of the Blue Mountain section of Oregon, where it has proved well adapted. In milling and baking qualities Redchaff apparently is about equal to or slightly better than Jenkin and Hybrid 128.

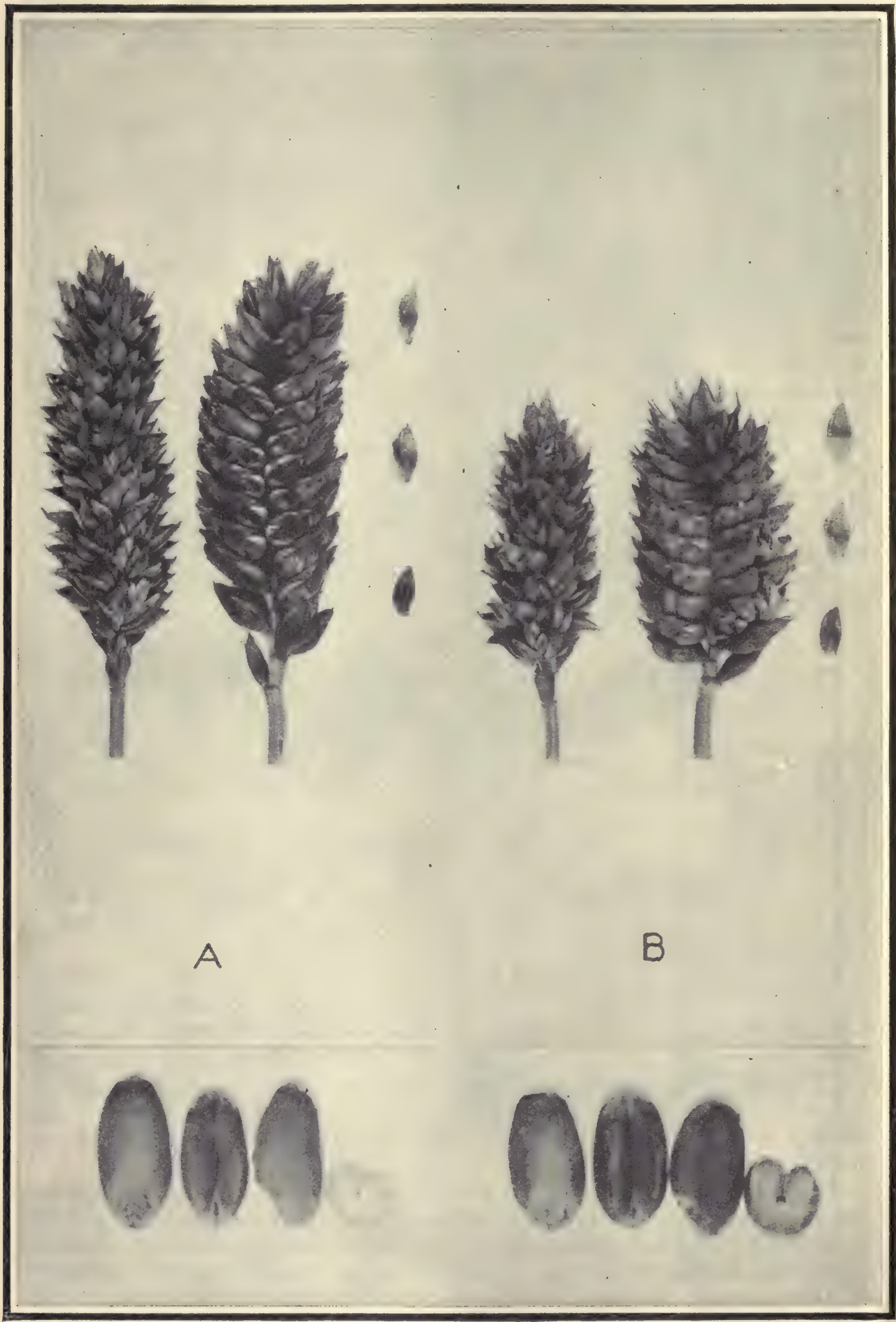

FIG. 11.—Heads, chaff, and kernels of Bluechaff (A) and Dale (B). Heads and chaff, natural size; kernels, magnified 3 diameters.

BLUECHAFF.

Bluechaff (Blue Chaff Calvert Club) differs from Redchaff in having a distinct bluish powder or bloom on the red or brown chaff color and is somewhat later than Redchaff (Fig. 11, *A*). The Bluechaff originated from a plant found in a field of wheat by A. C. Calvert, of Junction City, Oreg., in 1897. From this plant, having seven heads, the Bluechaff was increased until 1904, when it was first distributed in the upper Willamette Valley of Oregon. It is now grown in small quantities in that district and also in southern Oregon.

Little is known concerning the yields or milling quality of Bluechaff compared with other varieties grown in the same sections. In general, varieties of common wheat are more promising in western and southern Oregon than any club wheat. In recent years Bluechaff has given good yields from spring sowing in the upper Willamette Valley, where its acreage has been somewhat increased.

SECTION 4.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED; KERNELS RED.

This section includes only one commercial variety of club wheat.

DALE.

The Dale (Dale Gloria) variety is distinct among the club wheats in having purple or reddish stems at maturity. The stem of Dale wheat is short and stout; the heads also are short and compact and have a dark-brown chaff (Fig. 11, *B*). The variety, as commercially grown, is somewhat mixed and contains plants having white kernels and both brown and white chaff. It is a spring wheat and ripens earlier than most of the club wheats.

This variety originated from a plant found in a field of wheat by William H. Dale, of Helix, Umatilla County, Oreg., in 1900. The seed was increased to 4,000 bushels by 1904.

A few thousand acres of Dale wheat are grown in northeastern Oregon and southeastern Washington. Not much is known concerning its yielding ability or quality, but apparently it is inferior to other club wheats.

SECTION 5.—HEADS BEARDLESS; CHAFF VELVETY, WHITE OR YELLOW; KERNELS RED.

In this section there is only one variety commercially grown.

COPPEI.

The Coppei (Coppei Club) wheat is easily distinguished from most other club wheats by the velvety chaff (Fig. 12, *A*). It is a winter wheat, but if spring sown will mature late in the season. This variety originated from a plant found in a field of Little Club by J. L. Harper, of Waitsburg, Wash., in 1907. The wheat was found in a field belonging to W. G. Preston, located near Coppei Creek, 3 miles south of Waitsburg. It was grown and increased until 1911, when it was first distributed. From the appearance of Coppei it is believed by the writers to be the result of a natural cross between Little Club and Jones Fife, the latter being a soft red winter common wheat having velvety chaff.

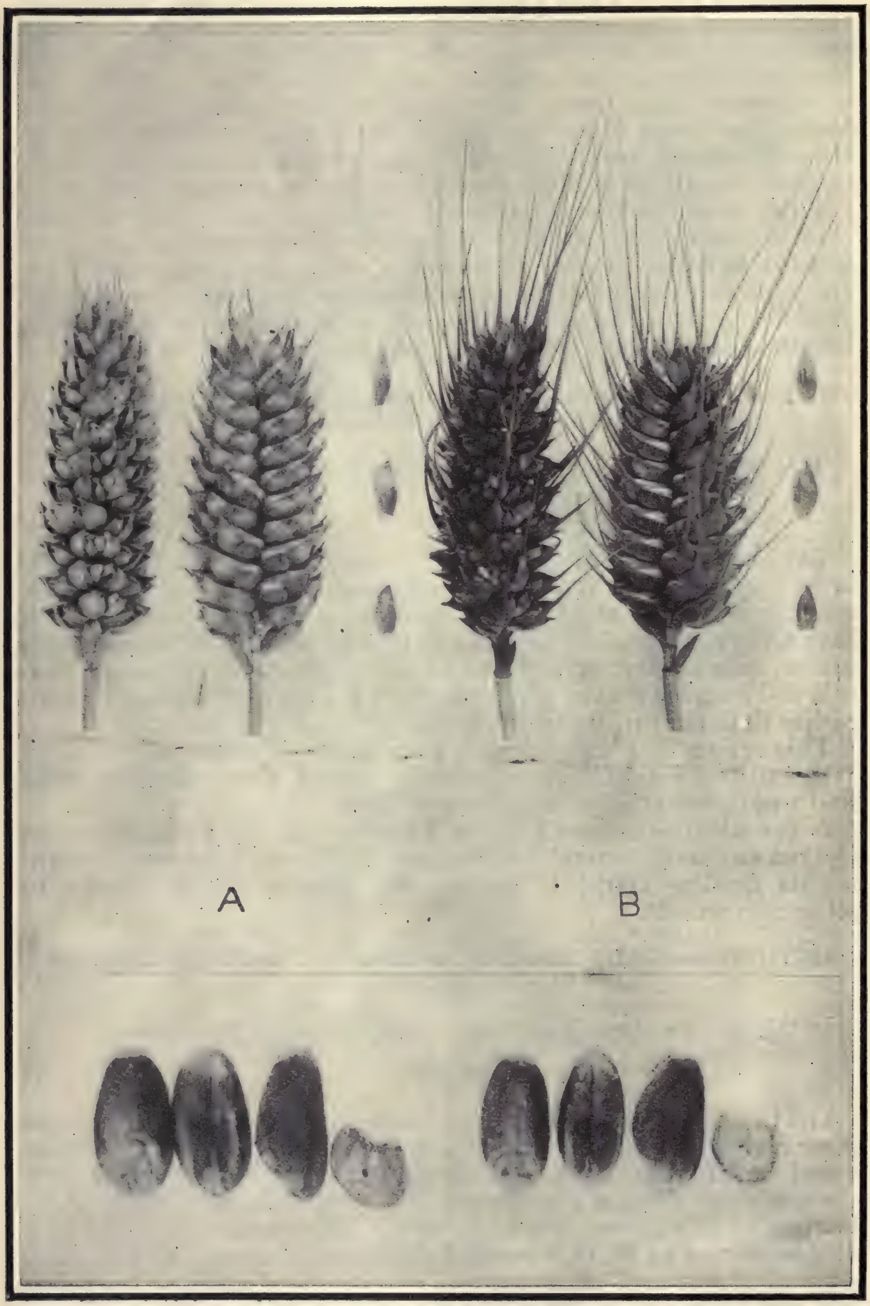

FIG. 12.—Heads, chaff, and kernels of Coppei (A) and Mayview (B). Heads and chaff, natural size; kernels, magnified 3 diameters.

Until recently Coppei has not been extensively grown. In 1919 it was reported only from two counties in southeastern Washington, where about 5,000 acres were grown. Its acreage in recent years has been increasing, especially in Whitman County, Wash.

Coppei yields nearly as well as Hybrid 128. It apparently is not superior to Hybrid 128 in milling and baking value, and it generally has a lower market value.

SECTION 6.—HEADS BEARDLESS; CHAFF VELVETY, BROWN OR RED; KERNELS WHITE.

This section includes one variety, of little importance.

WILBUR.

Wilbur (Early Wilbur) differs from Coppei in being shorter and earlier and in having brown chaff and white kernels. It is grown mostly as a spring wheat. This variety originated from a head of wheat found in a field of Jenkin by W. J. Mariner, of Blalock, Oreg., about 1899. The wheat was named Early Wilbur because of its comparative earliness and because the seed of the Jenkin wheat had been obtained from Wilbur, Wash. Wilbur is now grown only to a slight extent in three counties in eastern Oregon. This variety is better adapted to dry sections than most of the other club wheats, but even in these districts is usually considerably outyielded by winter and spring varieties of common wheat. It could well be entirely replaced by adapted varieties of hard red winter or white common wheat.

SECTION 7.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED; KERNELS RED.

This section is represented by a single variety, which differs from the other club wheats in being bearded.

MAYVIEW.

The Mayview variety has bearded club-shaped heads with glabrous brown chaff and soft red kernels (Fig. 12, *B*). The stems usually are white or yellow at maturity, but may show a trace of purple on the lower joints. The plants are of medium height and late. It is a spring wheat, but usually is grown from fall sowing.

Mayview originated from a selection found in a field of Goldcoin or Fortyfold wheat near May View, Wash., about 1911 or 1912. It was named Mayview by Prof. E. F. Gaines, cerealist of the Washington Agricultural Experiment Station, in 1917, when he first observed commercial fields of the variety in Washington. The variety probably originated as a result of a natural field cross between a club variety and a bearded variety of common wheat. Wheat plants similar to Mayview have been found as mixtures in fields in Idaho and Montana.

Mayview was grown in considerable quantity for a few years in the vicinity of its place of origin, but owing to its bearded heads it did not become popular. It has yielded less than Hybrid 128 and apparently has largely disappeared from cultivation.

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FARMERS' BULLETIN No. 1304

The DURUM WHEATS

1862 1889

THE DURUM WHEATS are all spring varieties with thick, compact heads, long stiff beards, and large hard kernels. They are grown principally in the northern Great Plains area, where they are best adapted because of their resistance to drought and rust, which enables them to outyield other spring wheats. The States leading in their production are North Dakota, South Dakota, and Montana. About 3,500,000 acres are grown annually in the United States.

Durum wheat is used largely for making semolina, from which macaroni, spaghetti, and similar products are made. Domestic manufacturers use less than half the annual production, the rest being mostly exported. The price of durum wheat often is less than that of equal grades of hard red spring wheat.

There are 12 varieties of durum wheat commercially grown in the United States. These differ in their adaptation and yielding ability, resistance to drought and rust, and in the quality of their grain, as well as in their appearance.

Kubanka is the variety best adapted for all the varying conditions in the sections producing durum wheat. It is a high-yielding wheat, considerably resistant to rust, of good milling quality, and best adapted for making both macaroni and bread.

Acme and Monad are two similar amber durum varieties which are very resistant to stem rust. Acme is the highest yielding durum variety in most of South Dakota, and Monad the best yielding variety in North Dakota. Both produce macaroni of a grayish color, considered by manufacturers less salable than that made from Kubanka wheat.

Mindum is the most productive durum variety in Minnesota. It is somewhat resistant to stem rust and makes macaroni of good color.

Peliss is the best yielding durum variety in the higher and drier sections of Montana and Wyoming, where rust does not occur. It is not equal to Kubanka wheat for bread making, but gives an excellent color in macaroni manufacture.

Washington, D. C. Issued January, 1923

THE DURUM WHEATS.[1]

J. Allen Clark, *Agronomist in Charge*, and John H. Martin, *Agronomist, Western Wheat Investigations, Office of Cereal Investigations, Bureau of Plant Industry.*

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WHAT ARE DURUM WHEATS?

THE DURUM WHEATS all are spring varieties with long stiff beards, and most of them have short, thick, compact heads. The heads are flattened across the sides rather than along the faces of the meshes, as with common wheat. Most of the varieties have white (amber) kernels, and the grain is used chiefly for the manufacture of a granular flour called semolina, from which macaroni, spaghetti, and other alimentary pastes are made.

The durum varieties have very hard kernels. Because of this distinctive character they are classed as a separate division or species (*Triticum durum*) from the common bread wheats (*Triticum vulgare*). Under the Official Grain Standards of the United States they are graded as "(Class II) Durum wheat." An average of about 3,500,000 acres, or about 6.4 per cent of the wheat acreage of the United States, is devoted annually to the production of this class of wheat. There are 12 varieties commercially grown.

WHERE GROWN.

The durum wheats are grown principally in the northern Great Plains area. The States leading in their production are North Dakota, South Dakota, and Montana. A considerable acreage also is grown in Nebraska, Colorado, Minnesota, and Wyoming. The section of heaviest production of durum wheat lies just west of the Red River Valley in North Dakota and comprises an area from

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[1] The information given in this bulletin is based upon (1) varietal experiments conducted by the Office of Cereal Investigations of the Bureau of Plant Industry, United States Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) a survey of the wheat varieties of the United States, in cooperation with the then Bureau of Crop Estimates, based upon 19,000 returns from 70,000 questionnaires sent to crop correspondents; (4) several years of personal observation by the writers of the wheat fields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Milling-Investigations Section of the Bureau of Markets and Crop Estimates (now a part of the Bureau of Agricultural Economics), in cooperation with the Office of Cereal Investigations, and also by the State agricultural experiment stations.

50 to 150 miles wide, extending from the northern part of South Dakota to the border of Canada. The distribution of durum wheat in the United States in 1919 is shown on the map (Fig. 1). This distribution is quite different from that of 1909, which is shown in Figure 2. It will be noted that during the past 10 years the center of durum acreage has moved northward and westward.

AREAS TO WHICH ADAPTED.

The durum wheats are fairly well adapted to the region between the Rocky Mountains and the Mississippi River, where spring wheats are grown. This in general includes the Great Plains area and the upper Mississippi Valley. From northern Iowa and Nebraska southward, winter wheats are more successfully grown than spring wheats. The durum wheats therefore are not well adapted to this area or to the humid areas of the entire eastern United States. In the Pacific Coast States and the intermountain districts of the West, other classes of wheat consistently outyield the durum varieties. In the northern spring wheat region, however, the durum varieties generally outyield the varieties of spring common wheat. In the subhumid parts of this region, including Wisconsin, Minnesota, eastern South Dakota, and the Red River Valley of North Dakota, durum wheats often develop a soft, starchy kernel and therefore are not well adapted, although they usually outyield the spring common wheats. Were it not for the resistance of the durum wheats to stem rust they should not be grown in the subhumid section.

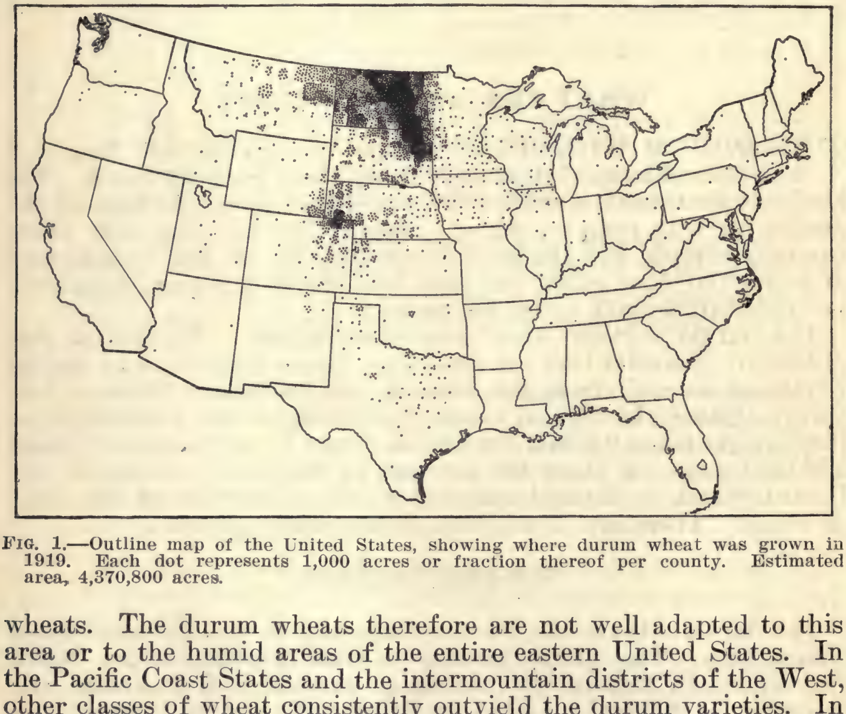

FIG. 1.—Outline map of the United States, showing where durum wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 4,370,800 acres.

In the drier Great Plains area the durum varieties are best adapted and have consistently given higher yields than the spring common wheats. Under the semiarid conditions of this latter section, durum wheats usually develop hard, bright, vitreous, amber-colored kernels, which are well suited for the manufacture of semolina and macaroni. Because they are more resistant to drought and stem rust and also give good yields under favorable conditions, the growing of durum wheat in the northern Great Plains section has steadily increased during the past 20 years, and production is restricted only by the market demand.

USE OF DURUM WHEAT.

Since the early days of durum-wheat production, there usually has been an active foreign demand for this wheat. The development of a domestic market, however, has not kept pace with production, as flour mills were not equipped satisfactorily for grinding these wheats and there was little demand for the product. Some mills began grinding them, however, and recently large mills have been constructed for grinding durum wheat exclusively. A considerable trade in semolina and durum flour developed, and finally a large macaroni industry has been established. This industry now uses annually more than 20,000,000 bushels of durum wheat, or nearly half the average annual production in recent years. Durum wheat which is not exported or used by the macaroni industry is blended with other classes of wheat or flour and used for pastes, pastry, or bread making. Very little, if any, flour from durum wheat alone is used for bread making in the United States.

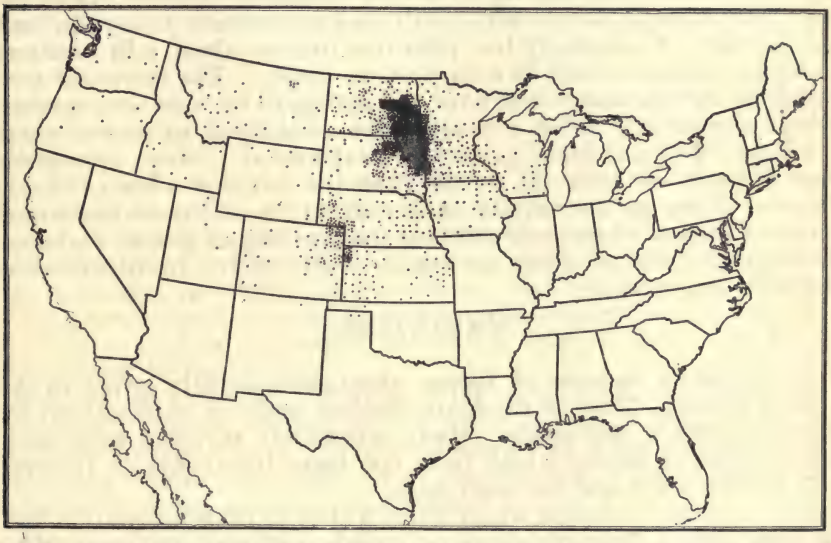

Fig. 2.—Outline map of the United States, showing where durum wheat was grown in 1909. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 2,502,872 acres.

PRICE OF DURUM WHEAT.

The export demand for durum wheat largely controls the market price. When this demand slackens, the price of durum wheat drops considerably. Previous to 1912 its price was always below that of hard red spring common wheat. From that year to 1919 the price of durum wheat at primary markets has been as high as equal grades of hard red spring wheat about half of the time, and occasionally the price of durum wheat has been the higher. During the period of the World War, when the price of wheat was fixed, the price of equal grades of durum and hard red spring was the same. Since 1919 the price of durum wheat usually has been considerably below that of hard red spring wheat.

Because of the greater resistance of durum wheats to rust and drought, which occur frequently in the northern spring-wheat region, durum wheat usually weighs more and grades higher in its class than hard red spring wheat grown under the same conditions.

The increasing quantities of durum wheat produced in recent years are the result of the nearly equal prices and the superior yields and higher grades which usually have been obtained. The still more recent low prices of durum wheat will tend to decrease its acreage and production. A relatively low price for durum wheat will continue to occur whenever there is a surplus in supply. The increased acre yields of durum wheat over hard red spring in the northern spring-wheat region will offset a lower price amounting to several cents a bushel. The risk from partial or total loss of a wheat crop from rust is much less with the durum than the common wheats. Aside from avoiding an oversupply of durum wheat, the most important phase of durum-wheat production is the growing of proper varieties. The durum varieties which are commercially grown are discussed in the following pages.

VARIETIES.

There are 12 varieties of durum wheat commercially grown in the United States. Most of these are distinct and can be identified by plant or kernel characters. Many additional varieties have been grown experimentally which have not been distributed to farmers and therefore are not discussed here.

The varieties of durum wheat differ widely in their adaptation and yielding ability, their resistance to drought and rust, and the quality of their grain, as well as in their external structure and appearance. A few varieties of similar appearance differ in origin and adaptation. For convenience of discussion the varieties of durum wheat are divided into five sections, on the basis of chaff, beard, and kernel characters.

DISTINGUISHING CHARACTERS AND VARIETIES.

SECTION 1.—Chaff glabrous (not velvety), yellow; beards yellow; kernels white (amber), midsized to large.
Kubanka, Kubanka No. 8, Arnautka, Mindum, Buford, Acme, Monad, Marouani.

SECTION 2.—Chaff glabrous (not velvety), white; beards white; kernels red, midsized.
Pentad (D-5).

SECTION 3.—Chaff glabrous (not velvety), white; beards black; kernels white (amber), very large.
Peliss.

SECTION 4.—Chaff velvety, white; beards black; kernels white (amber), large.
Velvet Don.

SECTION 5.—Chaff velvety, black; beards black; kernels white (amber), large.
Kahla.

SECTION 1.—CHAFF GLABROUS (NOT VELVETY), YELLOW; BEARDS YELLOW; KERNELS WHITE (AMBER), MIDSIZED TO LARGE.

The varieties included in this section, although somewhat similar in appearance, show quite different adaptations. Most of the durum varieties grown in the United States are in this section, the most important being Kubanka.

KUBANKA.

Kubanka wheat has smooth yellowish chaff, yellowish beards, and large white (amber) kernels (Fig. 3, *B*). The heads are thick and compact and nod slightly at maturity. This variety is resistant to some forms of stem rust and usually has shown fair resistance under field conditions. Several pure-line strains of Kubanka have recently been selected that are very resistant to stem rust.

Kubanka was introduced into this country from Russia by the United States Department of Agriculture, several different lots being obtained. The principal introduction (S. P. I. No. 5639; C. I. No. 1440) was made in 1900 by M. A. Carleton, cerealist of the Department of Agriculture, from the Uralsk Government in Russia. The seed was increased and distributed by the Department of Agriculture and the North Dakota and South Dakota Agricultural Experiment Stations. Several lots of durum wheat identical with the Kubanka were introduced under other names, but have not become commercially established. They were known under the names Beloturka, Gharnovka, Pererodka, Taganrog, and Yellow Gharnovka. The Kubanka, as originally introduced, was not pure, which has made improvement possible by the pure-line selection method. A small percentage of red kernels was in the original shipment and is still present in the variety.

Kubanka is grown in Colorado, Minnesota, Montana, North Dakota, South Dakota, Wisconsin, and Wyoming, and probably also in several additional States. It is not known just what proportion of the durum wheat now grown is of the Kubanka variety, but it is second only to Arnautka in total acreage.

The Kubanka is the best-adapted variety for all the varying conditions in the producing durum-wheat sections. For years it has produced consistently high yields in the northern Great Plains section. In the higher and drier western portions of the Great Plains area, including eastern Montana, Wyoming, and Colorado, the Kubanka has been outyielded by the Peliss variety.

In the subhumid section east of the Great Plains area, where stem rust is often an important factor, the Kubanka has produced higher average yields than the Arnautka variety in recent years. It has been outyielded, however, by the more rust-resistant varieties, Acme and Monad, in South Dakota and North Dakota, and by Mindum in Minnesota.

Although usually resistant to the common forms of stem rust under field conditions, Kubanka sometimes suffers considerable rust injury. It is more resistant to rust, however, than Arnautka, Peliss, Kahla, and Velvet Don and should be grown in preference to these varieties in the Dakotas and Minnesota.

In both milling and baking quality and for semolina and macaroni manufacture, the Kubanka equals or excels all other durum varieties grown in the United States.

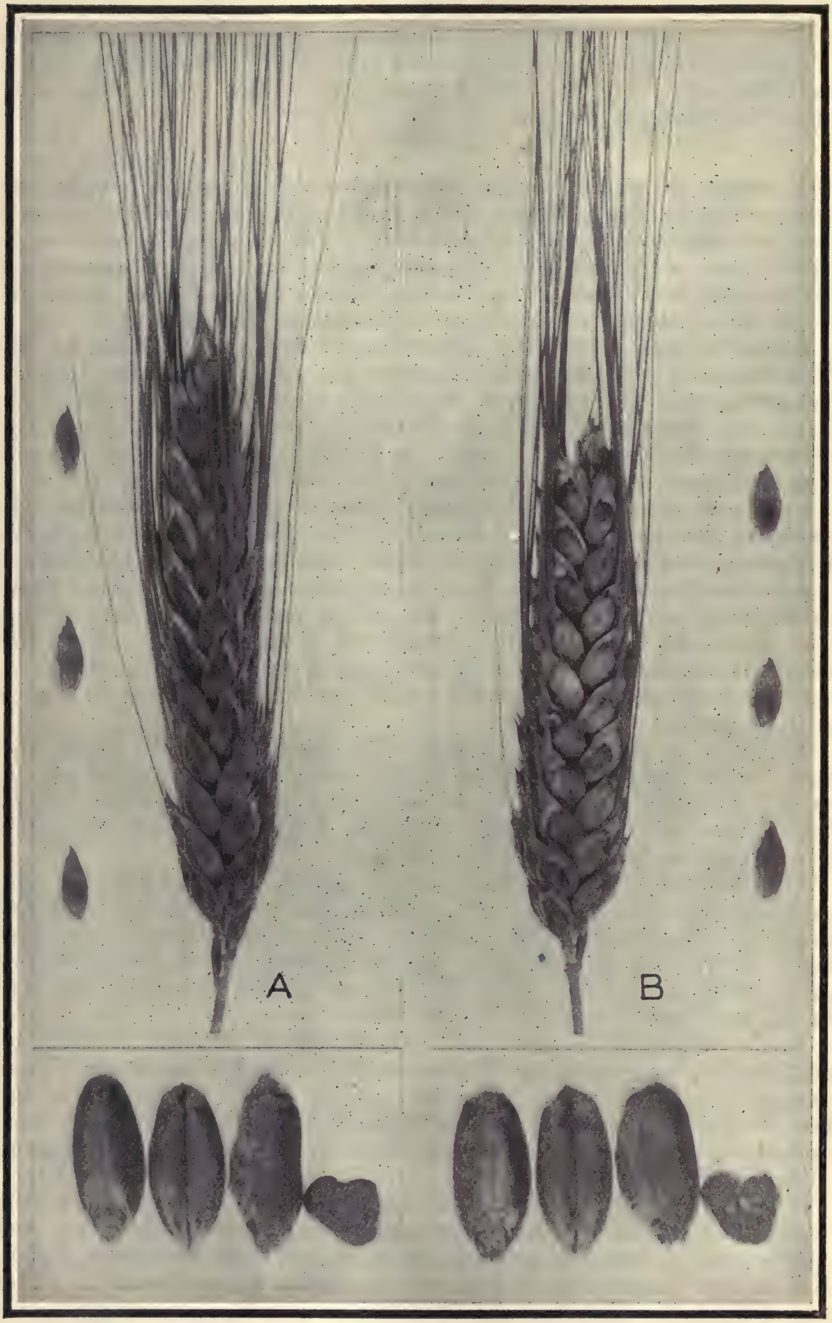

FIG. 3.—Heads, chaff, and kernels of Arnautka (*A*) and Kubanka (*B*) wheats. Heads and chaff natural size; kernels magnified 3 diameters.

KUBANKA NO. 8.

Kubanka No. 8 is a pure-line selection from Kubanka, identical in appearance but a better yielder in western North Dakota. It is much more susceptible to stem rust than the original Kubanka and principally for that reason has not yielded well over a wider area. This selection was made from Kubanka (C. I. No. 1440) in 1906 by Prof. L. R. Waldron at the Dickinson substation in North Dakota. It was distributed to growers in western North Dakota as early as 1911. Further distributions have been made during most years since that date, but on the farms the identity of the selection usually has not been preserved, so that the extent of its present distribution is not known. The quality of the grain of this selection appears from experiments to be equal or slightly superior to the original Kubanka.

ARNAUTKA.

Arnautka (known also as Goose, Nicaragua, Pierson, and Wild Goose) is probably the most widely grown variety of durum wheat. It differs from Kubanka in being taller and in having a longer, more slender, and more nodding head (Fig. 3, *A*). The kernels of Arnautka are slightly longer and more slender than those of Kubanka. The chaff of Arnautka has longer and sharper "beaks" (short beards on the outer chaff) than that of Kubanka. Arnautka is more susceptible to stem rust than Kubanka. It also contains a greater mixture of other types of durum wheat, including red kernels, than Kubanka.

The Arnautka variety was first imported into this country by the United States Department of Agriculture in 1864. Most of this variety now grown, however, probably was brought to this country originally by early immigrants from Russia. It was grown by them in North Dakota, where it was called Wild Goose. Some of this Arnautka (Wild Goose) wheat was obtained from T. N. Oium, of Lisbon, N. Dak., and distributed by the department in 1900 and later, together with other durum varieties. In Texas, Arnautka has been grown under the name of Nicaragua since the early nineties. The Pierson wheat grown in South Dakota is also the Arnautka variety.

The Arnautka has been the most widely grown durum variety. In recent years, however, it is being replaced rapidly by Kubanka and other more rust-resistant varieties. Most of the wheat grown simply as durum or macaroni wheat is the Arnautka variety.

Formerly Arnautka appeared to be best adapted to the subhumid and humid sections of the northern spring-wheat region, but during the last few years it has been severely attacked by stem rust in these sections. As a result, it recently has been outyielded by Kubanka in the more humid sections, as well as in the semiarid portion of the northern Great Plains area where it always has yielded less than Kubanka. The growing of Arnautka, therefore, could be discontinued with profit to the grower.

For flour and bread making Arnautka is slightly inferior to Kubanka, but for semolina and macaroni it probably is equal to Kubanka.

MINDUM.

The Mindum variety greatly resembles Arnautka in general appearance. It differs, however, in being more resistant to stem rust and in having a much shorter brush (tuft of hairs) on the tip of the kernels. The beards of Mindum are slightly longer than those of Arnautka, and it differs slightly in a few other characters. Being a pure-line selection, Mindum as commercially grown is more free from mixtures than Arnautka.

Mindum was first found as a mixture in a field of common wheat at the Minnesota Agricultural Experiment Station in 1896. After further selection and considerable testing it was distributed to Minnesota farmers in 1917.

It is now grown in Minnesota and North Dakota, principally in the Red River Valley section. It is of most importance in Kittson and Red Lake counties in Minnesota, and it is rapidly becoming more widely grown.

Mindum has outyielded all other spring-wheat varieties in Minnesota. Although not extremely rust resistant, being about equal to Kubanka in this respect, it is able to produce high yields in spite of the rust. Mindum should replace other durum varieties now grown in Minnesota.

For bread making Mindum is inferior to both Kubanka and Arnautka, because of the poor expansion of its loaf. For macaroni manufacture, however, it has good color and apparently is equal to either of these varieties.

BUFORD.

The Buford variety is very similar to Kubanka, but it has a longer and more slender head, somewhat approaching the Arnautka in shape. The kernels are long and thick and slightly larger than those of Kubanka. It is not very resistant to stem rust.

Buford is a selection from the Taganrog variety, made in 1909 by F. R. Babcock, of the Bureau of Plant Industry, at Williston, N. Dak. It was distributed in 1917 from the Williston substation of the North Dakota Agricultural Experiment Station.

Buford wheat is grown now to a limited extent in northwestern North Dakota and northeastern Montana. This variety has given high yields in experiments at the Williston (N. Dak.) substation, where it outyielded Kubanka during six consecutive years. It has been outyielded at this station by the Acme, Monad, and Pentad (D-5) varieties. Because of its susceptibility to stem rust, Buford is well adapted only to a limited area where rust does not occur commonly.

For bread making Buford is inferior to the other amber durum varieties, but as far as known it is equal to Kubanka for the manufacture of semolina and macaroni. Except in the section where it has been distributed, Buford probably should not be grown extensively.

ACME.

The Acme variety has shorter stems, heads, and kernels than Kubanka and is much more resistant to stem rust. The heads of Acme also are smaller and not as thick as Kubanka heads (Fig. 4, *A*).

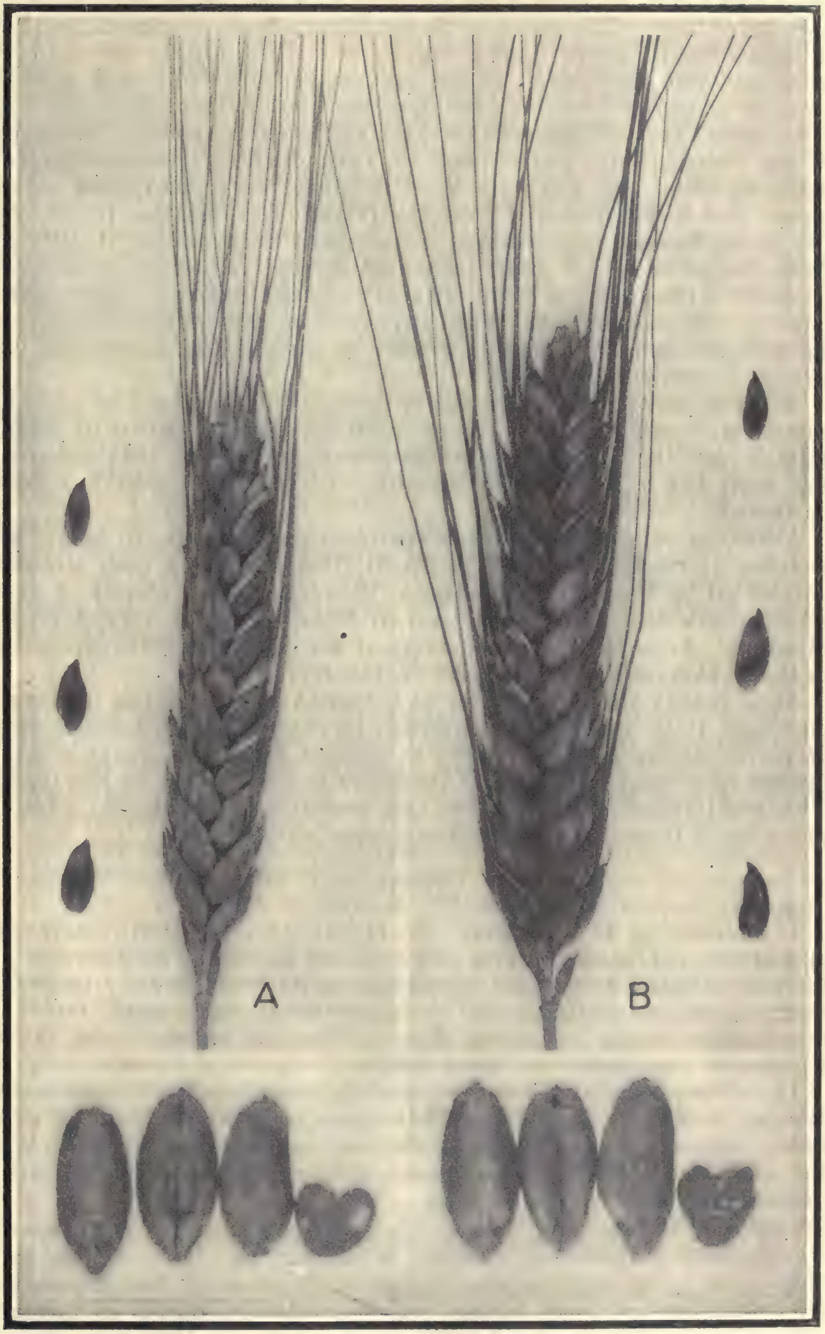

FIG. 4.—Heads, chaff, and kernels of Acme (*A*) and Kahla (*B*) wheats. Heads and chaff natural size; kernels magnified 3 diameters.

The kernels of Acme are only midsized, pointed at the germ end and blunt at the brush end, and have a somewhat boat-shaped appearance or outline. The straw of Acme is comparatively weak, so that it lodges easily under humid conditions. It is highly resistant to stem rust and has seldom, if ever, suffered injury from that disease.

Acme originated from a pure-line selection of Kubanka (C. I. No. 1516) made at the Highmore (S. Dak.) substation by M. J. Champlin, of the United States Department of Agriculture. The selection was made in 1909, and after its high yielding power had been determined seed was distributed from the Highmore substation in 1916 by the South Dakota Agricultural Experiment Station. As it differed from Kubanka it was given the name Acme. Although it was distributed in the spring of 1916, its rust resistance was not known until later in that season, when rust appeared in destructive abundance. This resistance to rust, together with its high yields, caused the variety to become popular.

Acme is grown now quite widely in South Dakota and to a slight extent in North Dakota. About 5,000 acres were grown in South Dakota in 1919. Most of the Acme grown previous to 1921 was used for seed, but a considerable quantity of the 1921 crop has been marketed.

Acme has outyielded all other spring-wheat varieties in nearly all sections of South Dakota. In North Dakota it has been slightly outyielded by Monad. In Montana, Wyoming, and Colorado it generally yields less than Peliss, and in Minnesota it is outyielded by Mindum. Acme, then, is best adapted for South Dakota, especially in the sections where rust occurs frequently.

Acme is only slightly inferior to Kubanka and Arnautka for bread making. It is considerably inferior, however, for the manufacture of macaroni, as it often yields a product of a dull grayish color instead of a bright amber and therefore is not desired by the trade. This has limited the market for this variety and resulted in a lower price for it than for other amber durum varieties.

MONAD.

The Monad or D–1 (Durum No. 1) variety is similar to Acme in appearance. The size, shape, and color of the heads and kernels of the two varieties are almost identical, and they are equally resistant to stem rust. Monad also has a comparatively weak straw, but it is not quite as easily lodged as Acme. The two varieties also differ slightly in the quality of the grain.

The Monad variety was obtained in the Saratov Government, Russia, in 1903 by Prof. H. L. Bolley, of the North Dakota Agricultural College, who was making a study of the flax industry of Europe for the United States Department of Agriculture. Several other introductions of wheat were made at the same time, all of which were grown by Professor Bolley and his assistants at the North Dakota Agricultural Experiment Station from 1904 to 1910. During this period the introductions were subjected to selection for disease resistance. Seed of four durum varieties was distributed to farmers and to the Dickinson and Langdon substations by Professor Bolley in 1911. One of these was designated as D–1 (Durum No. 1). The identity of this variety on the farms, however, nearly became lost.

In 1917, after its value had become apparent at the Dickinson substation, D–1 was named Monad. During the rust epidemics of 1915 and 1916 the extreme resistance of Monad was strikingly apparent. Because of this and its high yield seed of this variety has been increased and distributed in recent years by the North Dakota Agricultural Experiment Station. In 1919 the county agent of Stutsman County, N. Dak., found the variety widely grown in his territory from seed furnished a farmer by Professor Bolley in 1911. About 3,700 bushels of this seed were distributed in 1920. Much of the product of this was used for seeding in North Dakota in 1921. Although some had become mixed on the farms, it helped to meet the demand for seed of this rust-resistant amber durum variety. Most of the Monad wheat grown previous to 1922 has been used for seed.

In experiments Monad generally has outyielded all other varieties of wheat in North Dakota. It has been outyielded in Minnesota by Mindum and in South Dakota by Acme. In general, however, Monad is well adapted for growing in the portions of these States where stem rust has been destructive.

In milling, Monad usually produces less flour than Acme, but it is better than that variety for bread making and is nearly equal to Kubanka. Like Acme, however, it is inferior to Kubanka for the manufacture of macaroni, as it yields a product of a dull grayish color. From limited experiments Monad appears only slightly better than Acme in this respect. This is likely to cause some discrimination and a lower price for it than for the other amber durum varieties except Acme.

MAROUANI.

The Marouani variety is somewhat similar to Arnautka, but is earlier and taller and has longer heads, beards, and kernels. It is the tallest of the durum varieties, and perhaps the tallest wheat grown in the United States. It is not as rust resistant as Kubanka and several other varieties.

Marouani was introduced into the United States from Algeria by the Department of Agriculture in 1901. It has been distributed to some extent from the experiment stations at Hays, Kans., and Amarillo, Tex.

This variety has given good yields in the central and southern sections of the Great Plains area in comparison with other spring wheats. These sections, however, are better adapted to the production of hard winter wheat. Spring wheat is not grown extensively except in seasons when winter wheat fails. When grown, Marouani is perhaps the highest yielding variety. It is not well adapted, however, to the northern spring-wheat region and therefore has not been grown there to any great extent. It apparently is similar to Kubanka in the quality of its grain.

SECTION 2.—CHAFF GLABROUS (NOT VELVETY), WHITE; BEARDS WHITE; KERNELS RED, MIDSIZED.

This section includes only one variety commercially grown, namely, the Pentad, or D–5, which differs from the other durum wheats in having red instead of white (amber) kernels. Several durum wheats, such as Velvet Don and Kahla, and to a lesser extent

Arnautka and Kubanka, also contain some slight mixtures of red kernels. Many of these mixtures have been separated and tested, but none is grown commercially.

PENTAD.

Pentad, or D–5 (Durum No. 5), is known also as "D–Fife," Ladd Durum, Red Durum, Resistant Fife, and Rustproof. This variety has chaff and beards nearly white instead of the usually yellow or brownish color of those of the varieties discussed in section 1. The heads are more slender and less compact than those of the other durum varieties grown in this country (Fig. 5, *A*). The kernels are short, boat shaped, pointed at the germ end, blunt at the tip end, and of a dull-red color. The plants are of medium height and are less easily lodged than those of Acme and Monad. Pentad is the most resistant to stem rust of any variety of wheat grown commercially in the United States.

Pentad was introduced from Russia in 1903 by Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station. It was first distributed from that station in 1911. It since has become rather widely grown, especially in North Dakota, on account of its extreme rust resistance. It also is grown now in Minnesota, Montana, Nebraska, South Dakota, and Wyoming. More than 50,000 acres of this variety were reported grown in 1919. The relatively low market price for the grain has checked its increase.

Pentad produces good yields both under favorable and under dry conditions. In general it does not yield more than Acme, Monad, or Kubanka, and usually not as much as these varieties. When severe epidemics of stem rust occur Pentad frequently outyields all other varieties except, perhaps, Acme and Monad. These latter two varieties are practically as productive as Pentad under conditions of extreme stem-rust injury. Pentad thus is adapted to sections where stem rust is of common occurrence. In these sections, however, other varieties, such as Mindum in Minnesota, Monad in North Dakota, and Acme in South Dakota, usually yield as well as Pentad.

The Pentad wheat gives a low yield of flour when milled. The flour also has the poorest quality for bread making of any of the durum varieties commercially grown. Loaves of bread baked from Pentad flour have a small volume and a very poor color and texture. The grain of Pentad is also not adapted for the manufacture of semolina and macaroni, being less valuable for these purposes than that of the Monad or Acme varieties.

SECTION 3.—CHAFF GLABROUS (NOT VELVETY), WHITE; BEARDS BLACK; KERNELS WHITE (AMBER), VERY LARGE.

This section includes only one variety, Peliss, which is grown commercially in the United States. Another variety, Castillione, or "Black Bearded Durum," which contains many mixtures, some of them similar to Peliss, is grown to a very small extent in South Dakota, but will not be discussed here.

PELISS.

The Peliss (Pelissier) variety is probably more commonly known on the farms as Black Bearded Durum. This variety is tall and vigorous. The heads are large, thick, and compact (Fig. 5, *B*).

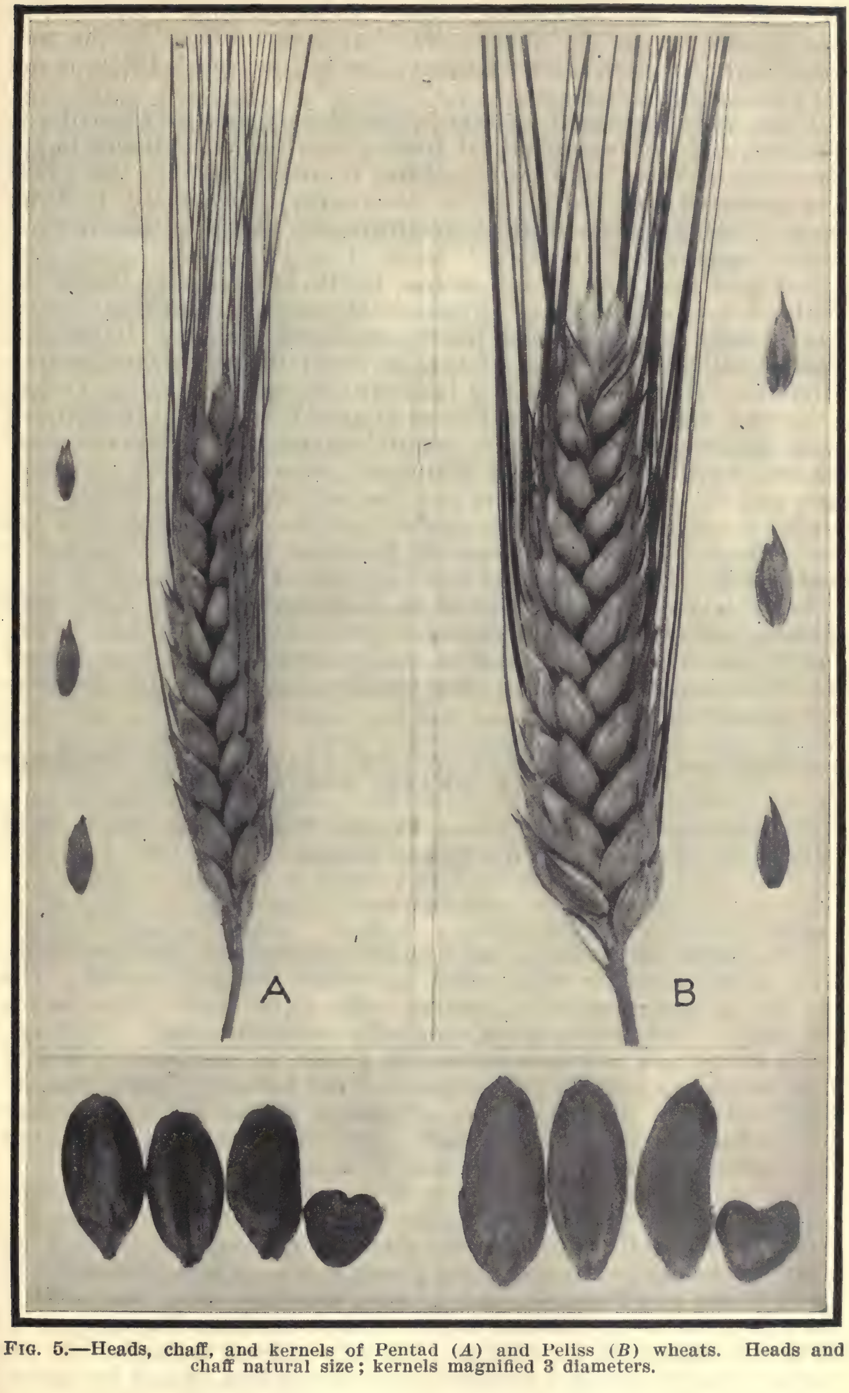

FIG. 5.—Heads, chaff, and kernels of Pentad (*A*) and Peliss (*B*) wheats. Heads and chaff natural size; kernels magnified 3 diameters.

The beards are long, stiff, and black, and the chaff is nearly white and similar to that of Pentad wheat. When thrashed Peliss can be distinguished from the other commercial durum wheats by the very long, thick, distinctly curved white (amber) kernels. Peliss is not very resistant to stem rust.

Peliss was introduced in 1900 by the Department of Agriculture. The original seed was obtained from a man named Pelissier in the Province of Oran in Algeria. After thorough testing, the wheat was increased and distributed in this country, principally in Montana, by the Department of Agriculture and the Montana Agricultural Experiment Station.

Peliss is now grown in Montana, North Dakota, and Wyoming. While it is most important in eastern Montana, a considerable acreage recently has been grown in western North Dakota. It has outyielded all other varieties of spring wheat in central and eastern Montana. Apparently, it also is about the highest yielding variety of spring wheat in eastern Colorado and Wyoming. In parts of these sections, however, winter wheat is more profitable than spring wheat. In the Dakotas and Minnesota, where stem rust is prevalent and the altitude is lower and the rainfall greater, Peliss generally is outyielded by other durum varieties. It therefore is not well adapted for growing east of Montana and Wyoming, but is best suited for the higher and drier sections of those States.

Peliss is but slightly inferior to Kubanka for flour and bread making and apparently is somewhat better suited than that variety for the manufacture of semolina and macaroni. The large size of the Peliss kernels is causing some trouble in cleaning with the present commercial machinery.

SECTION 4.—CHAFF VELVETY, WHITE; BEARDS BLACK; KERNELS WHITE (AMBER), LARGE.

This section includes only one variety, Velvet Don, and it is of only minor importance in the United States.

VELVET DON.

The Velvet Don variety has slender but compact bearded heads, with velvety or hairy white chaff and white (amber) kernels. The chaff is almost completely covered with white hairs. The beards are black. The variety is not especially resistant to rust. As originally introduced and as now usually grown in this country Velvet Don contains a considerable mixture of red kernels. There also are slight mixtures of other types of durum wheat having white or yellow beards and glabrous chaff. The white (amber) kernels of this variety are very similar to those of Arnautka.

Velvet Don was introduced into this country from the Don Territory of Russia in 1900 by the Department of Agriculture. It was distributed to a small extent shortly after its introduction, but did not prove especially promising. It is grown now only to a limited extent in Montana and Nebraska and possibly in a few other States. For several years the production of this variety has been discouraged, as it has not given as high yields as most other durum varieties. On the basis of yield alone the production of Velvet Don should be discontinued entirely. Little is known concerning the quality of its grain.

SECTION 5.—CHAFF VELVETY, BLACK; BEARDS BLACK; KERNELS WHITE (AMBER), LARGE.

In this section is discussed only one commercial variety, the Kahla. Very similar wheats are grown under several different names, but they are all so nearly identical that they are considered as one variety.

KAHLA.

The Kahla variety (known also as Black Don, Black Durum, Blackchaff Durum, Black Emmett, Black Swamp, Purple Durum, Red Swamp, and Sloat) has velvety or hairy black chaff, black beards, and white (amber) kernels (Fig. 4, *B*). The short fine hairs occur principally on the edges of the chaff. The kernels are large and white (amber). The heads are rather slender and are nodding. Kahla is not very resistant to rust.

Kahla was introduced into the United States from Algeria in 1901 by the Department of Agriculture. A similar wheat, containing mixtures of red kernels, was received from Russia under the name Black Don in 1900. Other introductions of this same type of wheat have been made by the department and probably by individuals as well. The Kahla wheat occasionally occurs as a mixture with other durum varieties. Both Kahla and Black Don were distributed for trial when first introduced by the department, but did not prove to be high-yielding varieties. In recent years, however, this wheat has been grown commercially in Montana, North Dakota, and South Dakota, and to a slight extent in other States. It relatively is unimportant except in a few local sections.

The yields of Kahla have been decidedly less than those of Kubanka and several other durum varieties, both in the Great Plains and in subhumid sections. As Kahla is not very resistant to rust, it is badly injured during severe rust epidemics and should not be grown in sections where rust occurs. It does best in the western Great Plains area, as it is early and quite resistant to drought, but it does not yield as well as other varieties of durum and hard red spring common wheat. Limited experiments with Kahla indicate that it is about equal to Kubanka in the quality of its grain.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1305

The SOFT RED WINTER WHEATS

SOFT RED WINTER WHEAT comprises about 30 per cent of the total wheat acreage of the United States, more than 20 million acres being grown in 1919. Most of the wheat grown in the eastern half of the United States belongs to this class. With the exception of the State of Washington this class of wheat is relatively unimportant in the western half of the country. The States leading in the production of soft red winter wheat are Missouri, Indiana, Ohio, Illinois, Texas, Kansas, Pennsylvania, and Oklahoma.

The soft red winter wheats are generally best adapted to humid areas where the winters are not too severe. They are able to withstand the effects of excessive moisture better than most of the other wheats, but are less resistant to drought and severe winter temperatures.

Flour made from this class of wheat contains less gluten and more starch than does flour from the hard red spring and hard red winter wheats, and so is preferred for pastry making and much of the home baking.

At least 66 distinct varieties of soft red winter wheat, known by nearly 400 different names, are grown commercially in the United States, and additional varieties are grown experimentally. These varieties differ widely in yield, adaptation, milling and baking value, and other characteristics. The most widely grown varieties in the United States in order of importance are Fultz, Fulcaster, Mediterranean, Poole, Red May, Red Wave, and Harvest Queen. The area of each of these varieties in 1919 varied from about 4,800,000 acres to about 1,000,000 acres.

Washington, D. C. Issued December, 1922

THE SOFT RED WINTER WHEATS.[1]

By CLYDE E. LEIGHTY, *Agronomist in Charge of Eastern Wheat Investigations*, and JOHN H. MARTIN, *Agronomist in Western Wheat Investigations, Office of Cereal Investigations, Bureau of Plant Industry.*

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THE SOFT RED WINTER CLASS OF WHEATS.

FIVE classes of wheat are now officially recognized in the United States, one of which is known commercially as soft red winter wheat. This class is composed of a large number of varieties having soft to semihard red kernels. They are grown almost exclusively from fall sowing. Most of the wheat grown in the eastern half of the United States belongs to this class. Two varieties of club wheat having red kernels, but which are grown mostly from spring sowing in Washington and Idaho, are classed as soft red winter in the Official Grain Standards of the United States, but are not considered in this bulletin.

WHERE GROWN.

The soft red winter wheats are grown chiefly in the eastern half of the United States (Fig. 1), where the climate is humid. This class of wheat is relatively unimportant in all the western half of the country with the exception of the State of Washington. The States leading in the production of soft red winter wheat, in the order of their importance, are Missouri, Indiana, Ohio, Illinois, Texas, Kansas, Pennsylvania, and Oklahoma. In these States the area of this class of wheat varies from about 3 million acres in Missouri to about 1 million in Oklahoma. It is practically the only class of wheat grown in the South Atlantic and Gulf States. More than 20 million acres of soft red winter wheat were grown in 1919. This was over 30 per cent of the total wheat acreage in the United States. The distribution of soft red winter wheat in the United States is shown on the map in Figure 1.

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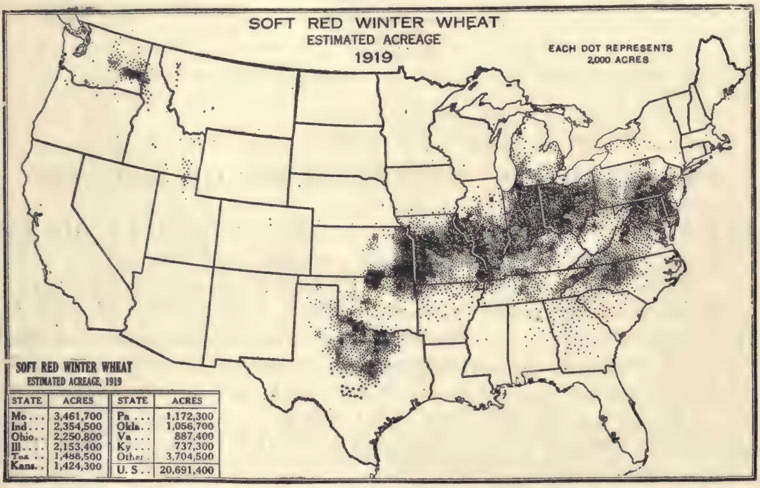
[1] The information given in this bulletin is based upon (1) varietal experiments conducted by the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) a survey of the wheat varieties of the United States, in cooperation with the then Bureau of Crop Estimates, based upon 19,000 returns from 70,000 questionnaires sent to crop correspondents; (4) several years of personal observation by the writers of the wheat fields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Milling Investigations Section, Bureau of Agricultural Economics, in cooperation with the Office of Cereal Investigations, and also by the State agricultural experiment stations.

AREAS TO WHICH ADAPTED.

The soft red winter wheats are best adapted to humid areas where the winters are not too severe. As a class they will not withstand as severe winter temperatures as the hard red winter wheats. They usually are less resistant to drought than the other classes of wheat. On the other hand, they will withstand the effects of excessive moisture better than most of the other wheats. Most of them have stiff straw and hence are not especially subject to lodging and so develop normally in wet seasons. None of the soft red winter wheats has shown any marked resistance to stem rust, leaf rust, or bunt (stinking smut), although the varieties differ in respect to their susceptibility to these diseases.



SOFT RED WINTER WHEAT
ESTIMATED ACREAGE, 1919

STATE	ACRES	STATE	ACRES
Mo . . .	3,461,700	Pa . . .	1,172,300
Ind . . .	2,354,500	Okla. .	1,056,700
Ohio. .	2,250,800	Va . . .	887,400
Ill. . . .	2,153,400	Ky . . .	737,300
Tex . .	1,488,500	Other .	3,704,500
Kans. .	1,424,300	U. S . .	20,691,400

FIG. 1.—Outline map of the United States, showing where soft red winter wheat was grown in 1919. This class of wheat occupies nearly one-third of the total acreage of all wheat and nearly one-half of the total acreage of winter wheat. The States leading in its production are Missouri, Indiana, Ohio, and Illinois.

In general, the soft red winter wheats are the best adapted varieties for those sections in the eastern United States having an annual rainfall of more than 30 inches. In Wisconsin, northern Michigan, and the northern New England States the winters are too severe for these winter wheats, so spring wheat is most frequently grown. In New York soft white wheat is usually grown. In Wisconsin and Iowa hard red winter wheat is more important. The soft red winter wheats are the best-adapted varieties in the Southern States, but wheat is not an important crop in these States. Very little wheat is grown on the Atlantic and Gulf Coastal Plains.

In Illinois, Iowa, Missouri, Kansas, Oklahoma, and Texas, there is an area in which both soft red winter and hard red winter wheats are adapted. This area may shift during periods of one or more years, owing to seasonal variations which affect one class of wheat more favorably than the other. In dry seasons in this area the hard red winter wheats usually outyield the soft red winter wheats, but in wet seasons the reverse is true. The soft red winter wheats suffer more from low temperatures. Market prices for the two classes of wheat also affect the relative acreage of each grown within the transition zone. New varieties of either soft red winter or hard red winter wheat also may change the relative adaptation for the two classes. Frequently soft red winter varieties are grown on the bottom lands and heavy soils to avoid the lodging which probably would occur if hard red winter wheats were grown under such conditions, while the latter are grown on the higher, drier, and lighter soils.

In parts of Ohio, Pennsylvania, New York, and Michigan, varieties of white winter wheat outyield most of the soft red winter wheats grown. Owing to the better quality for bread making and higher market price for the red wheat, however, it is grown more abundantly in all of these four States except New York.

Flour made from the soft red winter wheats contains less gluten and more starch than flour from the hard red spring and hard red winter wheats. Flour made from these hard wheats is generally preferred by commercial bakers of light bread because of the gluten quality. Large quantities of soft red winter wheat, both alone and in blends with hard wheats, are used, however, in the manufacture of bread-making flours. Small mills make a good flour for local consumption from the soft red winter wheats. The flour from these soft wheats is excellent for pastry making and home baking, and is much used for these purposes. The varieties of this class of wheat differ widely in milling and baking value. Some are nearly equal to hard wheats, while others are little better than club wheats for bread making. The better varieties, as grown in some sections of Kansas, Oklahoma, or Texas, in certain seasons, produce fairly hard kernels which are nearly equal to the best of the hard red winter varieties in milling and baking quality. On the other hand, the hard red winter wheats when grown in very humid regions become soft and starchy and of no better quality than the soft red winter wheats for the making of bread flours.

VARIETIES.

At least 66 distinct varieties of soft red winter wheat, known by nearly 400 different names, are grown commercially in the United States. Many additional varieties, not yet distributed to farmers, are being grown experimentally. A considerable number of varieties formerly of importance have partially or entirely disappeared from cultivation.

The varieties of soft red winter wheat differ widely in yield, adaptation, earliness, strength of straw, and milling and baking value, as well as in their external structure and appearance. Some varieties, although differing in their adaptation, can scarcely be distinguished from one another by appearance alone. Most of the important varieties of soft red winter wheat are each grown under several names which are not generally recognized as representing only one variety. Several of the old standard varieties have been exploited under new names from time to time. For convenience in discussion, the recognized varieties of soft red winter wheat are divided into eight sections on the basis of head and chaff characters. The synonymous names are given in the discussions of the recognized varieties.

DISTINGUISHING CHARACTERS AND VARIETIES OF SOFT RED WINTER WHEAT.

SECTION 1.—Heads beardless; chaff glabrous (not velvety), white or yellow. *Eastern grown:* Fultz, Trumbull, Ashland, Zimmerman, Walker, Rice, Oakley, Wyandotte, Flint, Purplestraw, Climax, Leap, Prosperity, Forward, Harvest Queen, Fultzo-Mediterranean. *Western grown:* Big Frame, Lofthouse, Buffum No. 17, Minhardi, Red Russian, Sol, Squarehead.

SECTION 2.—Heads beardless; chaff glabrous (not velvety), brown or red. *Eastern grown:* Poole, Portage, Russian Red, Red May, Illini Chief, Red Clawson, Rochester, China, Wheedling, Currell, Red Wave, Homer, Rupert, Resaca, Gold Drop, Rural New Yorker No. 6. *Western grown:* Fleming, Peterson, Odessa (eastern also), Squareheads Master.

SECTION 3.—Heads beardless; chaff pubescent (velvety), white or yellow. Jones Fife (eastern and western), Mealy, Triplet (western grown).

SECTION 4.—Heads beardless; chaff pubescent (velvety), brown or red. Grandprize.

SECTION 5.—Heads bearded; chaff glabrous (not velvety), white or yellow. Fulcaster, Mammoth Red, Nigger, Gipsy, Gladden, Valley, Sibley, Rudy, Silversheaf, Golden Cross, Nebraska 28 (western grown).

SECTION 6.—Heads bearded; chaff glabrous (not velvety), brown or red. Mediterranean, Red Rock, Diehl-Mediterranean, Goens, Cox (western grown).

SECTION 7.—Heads bearded; chaff pubescent (velvety), white or yellow. Pride of Genesee.

SECTION 8.—Heads bearded; chaff pubescent (velvety), brown or red. Penquite.

Section 1.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW.

This section consists of 23 commercial varieties varying greatly in many plant, head, and kernel characters. Sixteen of these varieties are grown almost exclusively in the eastern half of the United States and seven of them in the western half.

FULTZ.

Fultz is grown also under the names Ber Ban, Bluestem, Bluestem Fultz, Economy, Everitt's High Grade, Grains o' Gold, Halver, Hickman, High Grade, Improved English, Improved Fultz, Jersey Fultz, Little Red Jersey, McKennon, New Economy, Nixon, Perpetuated Fultz, Roosevelt, Rust Proof, Shamrock, Slickhead, Tennessee Fultz, Tipton Red, and Winter Pearl.

This variety has slightly inclined, rather tapering heads of medium length and compactness. The kernels are rather small, of a pale red color, and soft (Fig. 2, A). The plants are of medium height and midseason in maturity and have a purple or reddish straw when ripe.

Fultz originated from three heads found in a field of Lancaster (Mediterranean) wheat in Mifflin County, Pa., in 1862, by Abraham Fultz. This wheat was increased for several years and later widely distributed over the United States. In 1871 the United States Department of Agriculture distributed 200 bushels of this variety.

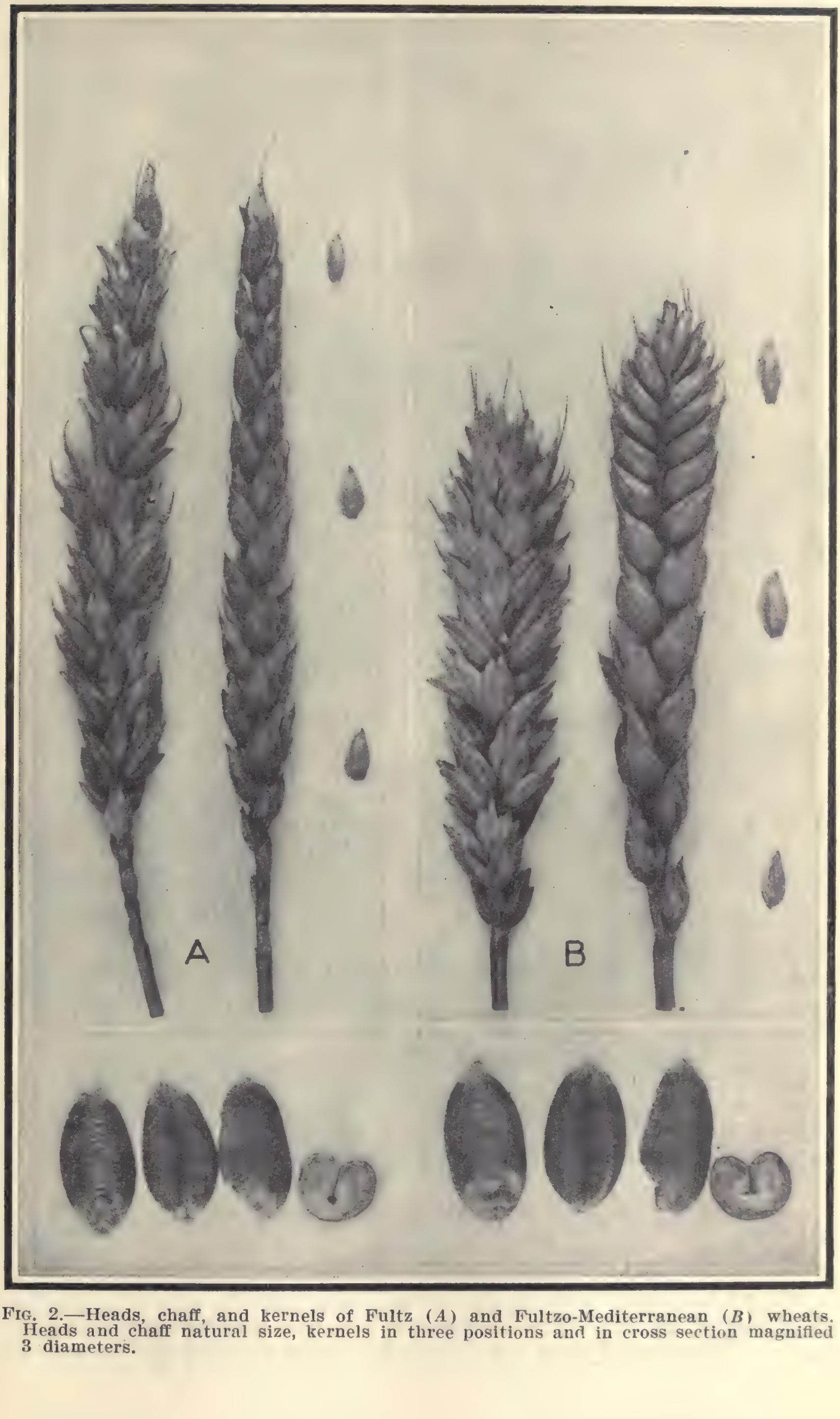


FIG. 2.—Heads, chaff, and kernels of Fultz (*A*) and Fultzo-Mediterranean (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

Fultz is now the third most important variety of wheat and the leading variety of soft red winter wheat in this country, about 4,800,000 acres being grown in 1919. This represented nearly one-fourth of the total acreage of soft red winter wheat. The States leading in the production of Fultz wheat are Missouri, Illinois, Indiana, Kansas, Ohio, Kentucky, Pennsylvania, Oklahoma, Maryland, and Virginia, each of which grows more than 100,000 acres annually. In 1919 about 1,600,000 acres of Fultz wheat were grown in Missouri. The distribution of Fultz wheat in the United States in 1919 is shown on the accompanying map (Fig. 3).

Fultz is adapted to a large area. It is one of the leading varieties in practically all States south of the Ohio River and in portions of several States north of the Ohio. In Kentucky and New Jersey it has outyielded practically all other varieties. In many States Fultz yields less than Fulcaster and some other bearded varieties, but nevertheless it is grown largely because it is beardless. Although a productive variety for general growing, it frequently is outyielded by other varieties in local districts. It probably could profitably be replaced by other varieties in many localities.

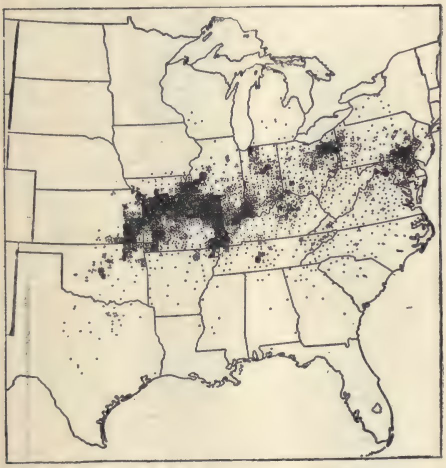


FIG. 3.—Outline map of a portion of the United States, showing where Fultz wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 4,801,100 acres.

The kernel of Fultz is rather soft, but its milling and baking qualities are good. Only a few of the soft red winter wheats surpass it in these qualities.

TRUMBULL.

Trumbull is taller than Fultz and has a stronger straw. Its straw is not as purple as that of Fultz and the heads are more erect. This wheat is a pure-line selection from Fultz made at the Ohio Agricultural Experiment Station some time before 1908, in which year it was first included in varietal experiments. It was increased and distributed later by that station, and is now grown in several sections of Ohio.

Trumbull has outyielded Fultz by from 2 to 4 bushels per acre in Ohio. It is one of the best varieties of wheat for that State, but little is known concerning its behavior in other States. Trumbull stands high among the soft red winter wheats in milling and baking quality, apparently being superior to Fultz in that respect.

ASHLAND.

Ashland is very similar to Fultz, but has a stronger straw and is claimed to be fairly resistant to scab. Ashland was selected from Fultz at the Kentucky Agricultural Experiment Station. It was distributed first in 1919 and is grown now to a limited extent in Kentucky. This variety has outyielded all others in comparative experi-

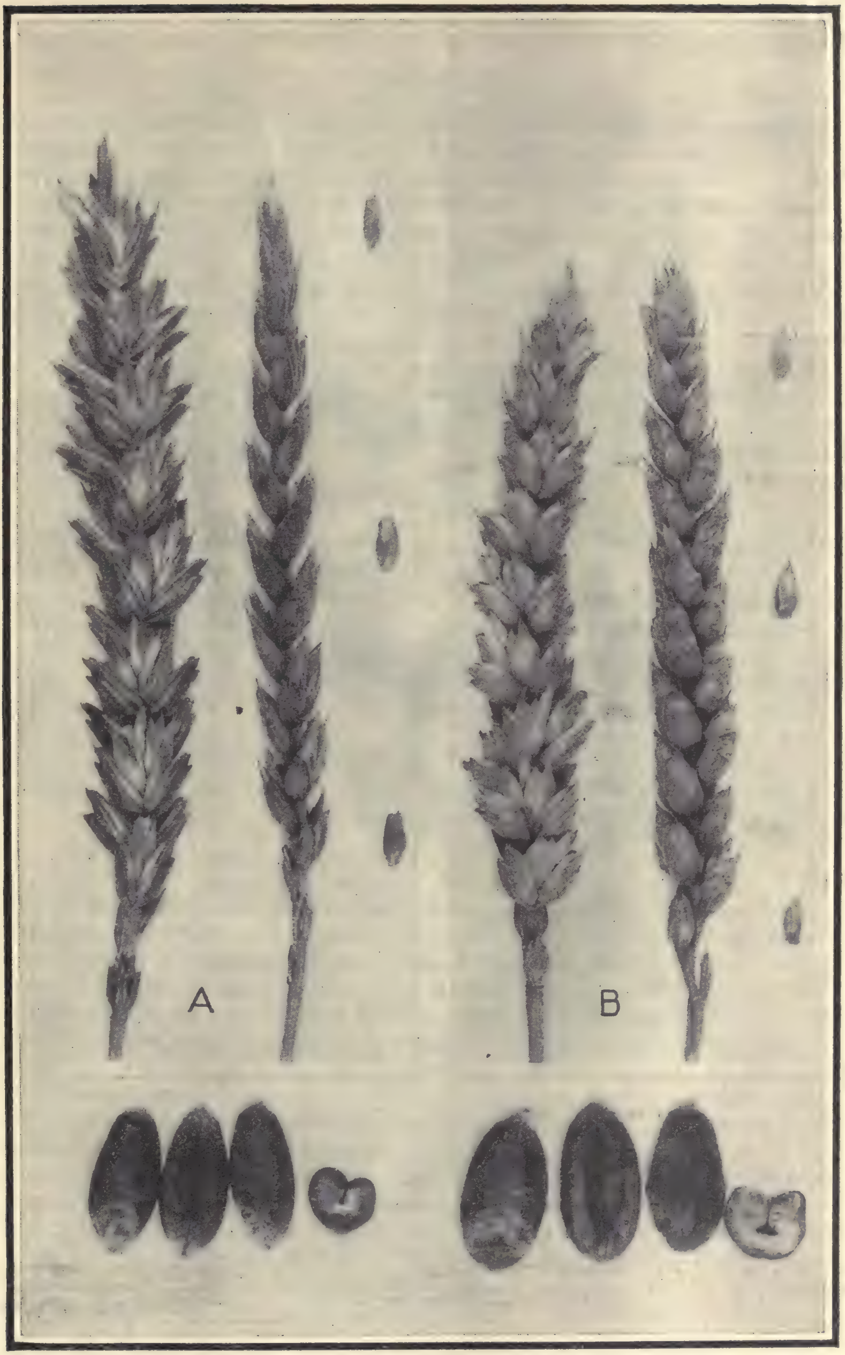


FIG. 4.—Heads, chaff, and kernels of Leap (*A*) and Walker (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

ments at the Kentucky Agricultural Experiment Station and is the most promising wheat for that State.

ZIMMERMAN.

Zimmerman is earlier than Fultz and has white instead of purple straw. The heads are very similar to those of Fultz but are slightly shorter. The kernels of Zimmerman are pale red, small, and rounded.

Zimmerman originated from three heads found in a field of wheat near Frederick, Md., by Henry Zimmerman, in 1837. It was increased by Mr. Zimmerman and first distributed about 1844. It formerly was grown widely in Maryland, Virginia, and Pennsylvania, but now is known to be grown only to a limited extent in Missouri and eastern Kansas.

Owing to its earliness Zimmerman yields well in certain seasons in Missouri and eastern Kansas. On the average, however, it is outyielded by Fulcaster, Fultz, Harvest Queen, and other varieties in these sections. Zimmerman wheat is about the same as Fultz in milling and baking quality.

WALKER.

Walker is similar to Zimmerman, but the heads and kernels (Fig. 4, B) also closely resemble Fultz. The origin of Walker is not known, but it has been grown in the United States for 50 or 60 years. It formerly was an important variety in the eastern United States, but at present less than 25,000 acres are grown annually. Walker is grown in seven States in the central and southern Mississippi Valley, as shown on the accompanying map (Fig. 5). This variety has not shown high comparative yields in the limited tests in which it has been included and probably could be replaced with profit by Fultz, Fulcaster, Mediterranean, or other varieties. It probably is about equal to Fultz in milling and baking value.

RICE.

The Rice variety (known also as Early Rice, Red Rice, and White Rice) is similar to Zimmerman. However, it has more tapering yet compact heads, longer tip beards, and harder kernels (Fig. 6, A).

The origin of Rice is not known. It has been grown in the United States for at least 40 years. In 1919 it was grown on about 30,000 acres in seven States in the southeastern part of the United States, as shown on the accompanying map (Fig. 7).

Rice wheat has been grown in very few comparative experiments in recent years. It has not appeared very promising, although it yields well in some seasons on account of its earliness. Apparently Rice could be replaced largely by such varieties as Fulcaster, Purplestraw, and Fultz in the sections where it is grown. Nothing is known concerning its milling and baking quality, but from the appearance of the kernels it probably is about equal to Fultz.

OAKLEY.

Oakley (Extra Early Oakley) is known also as Early Oakley, Norwood, and Neverfail. It differs from Fultz chiefly in being earlier and in having a more tapering, erect head. Like Fultz it has a purple straw.

The origin of Oakley is not known. It was grown in Kentucky about 30 years ago, but now is known to be grown commercially only on a small acreage in two counties of North Carolina.

Oakley was formerly a promising variety in Kentucky from the standpoints of both yield and quality. During later years better varieties have largely displaced it, and doubtless it could be entirely displaced with profit.

WYANDOTTE.

Wyandotte (Wyandotte Red) differs from Oakley chiefly in having nodding heads and in being taller. It was first obtained by the Ohio Agricultural Experiment Station in 1886 from T. Balliet, Nevada, Ohio. The original source of the wheat is not known. It formerly was grown in Ohio and Indiana, and a small acreage still is grown in Ohio.

Comparative experiments have shown that several other varieties are more productive than Wyandotte and it should be displaced by them. Little is known concerning the quality of Wyandotte.

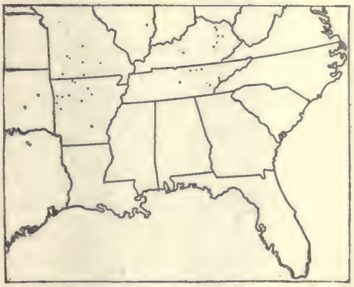


Fig. 5.—Outline map of the southeastern United States, showing where Walker wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 24,300 acres.

FLINT.

Flint (Red Flint) is known also as Early May, Little May, Little Red, Little Red May, May, Rappahannock, Red Davie, and Red May. It is somewhat similar to Fultz in kernel appearance, and in having purple straw, but is quite distinct from that variety. The heads of Flint are erect, oblong, rather compact, and have long tip beards (Fig. 8, A). It is earlier and slightly shorter than Fultz. Flint also is very similar to Zimmerman except in having purple straw.

Flint has been grown in the United States under various names for at least seventy or eighty years. Its origin is not known. There is much confusion in the names applied to this variety, several of them being used also for a brown-chaffed wheat discussed later as Red May. Flint wheat was grown on about 97,000 acres in 1919 in several eastern States, as shown on the accompanying map (Fig. 9). The States leading in the production of Flint are Virginia, North Carolina, South Carolina, and Illinois. Flint, owing to its earliness, is adapted to certain seasons and localities. In general, however, it produces lower yields than other varieties in the sections in which it is grown. It has given fair yields on the Mississippi bottom lands in Illinois and Missouri. In several counties in the south-central part of Virginia and in the adjoining portion of North Carolina, Flint is the leading variety of wheat. Apparently it yields as well, or better, than other varieties in this district. Nothing is known concerning the milling and baking value of Flint wheat, but the kernels are similar to those of Fultz.

PURPLESTRAW.

Purplestraw is known also as Alabama Bluestem, Bluestem, Early Purplestraw, Georgia Bluestem, Georgia Red, Mountain Purple-

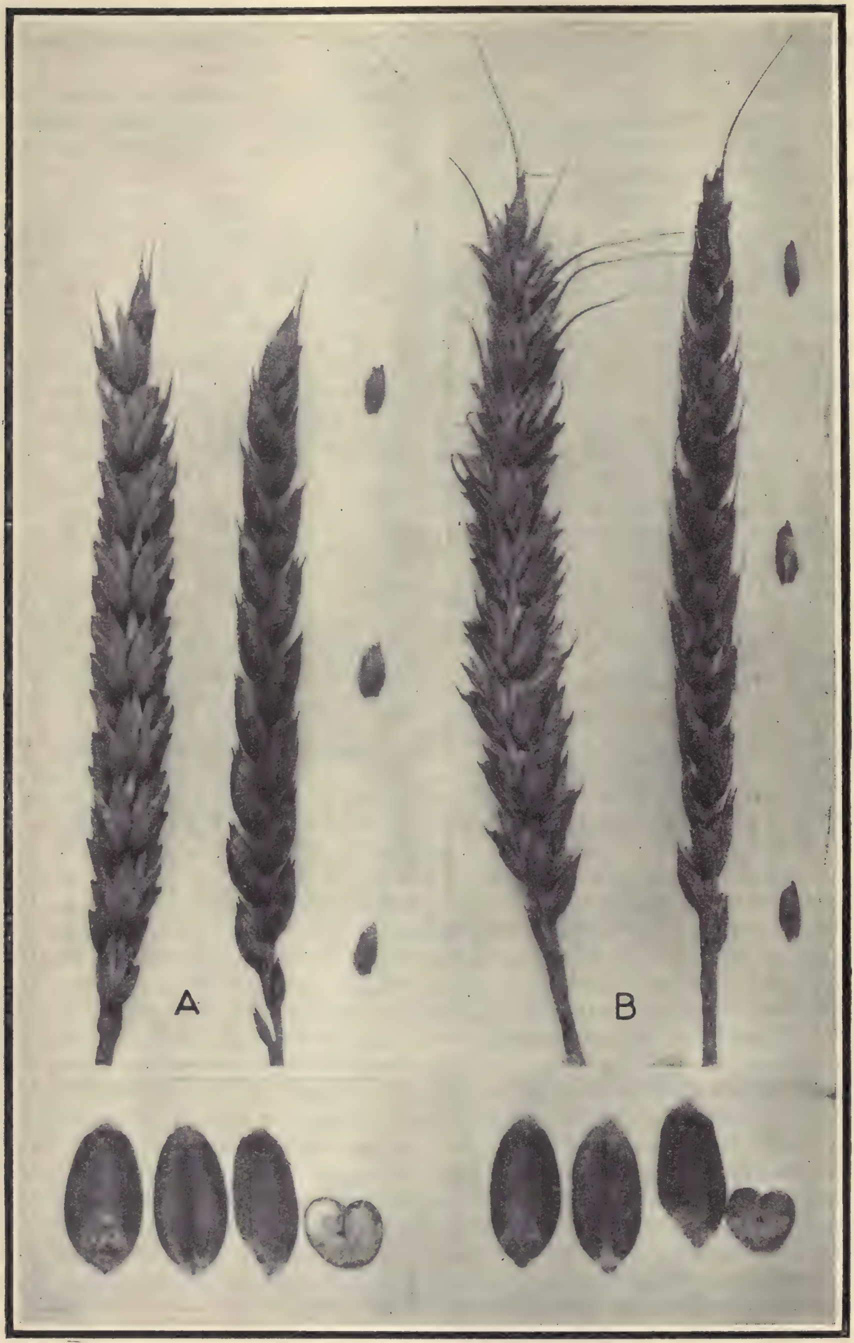


FIG. 6.—Heads, chaff, and kernels of Rice (*A*) and Buffum No. 17 (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

straw, and Ripley. This variety closely resembles Flint, but has shorter tip beards (Fig. 8, B). It is very early and is distinct from all other soft red winter wheats in that it will produce a crop from spring sowing. Although a spring wheat in this respect the plants have the appearance of winter wheat, and it is grown only as a winter variety. In the section where it is grown the winters are sufficiently mild to permit a hardy spring wheat to survive.

The source and date of the introduction of the Purplestraw variety are not known, but it has been grown in this country for at least 100 years. It is the leading variety of wheat in Georgia, Alabama, and South Carolina. About 273,000 acres of Purplestraw were grown in the United States in 1919, the distribution of which is shown on the accompanying map (Fig. 10).

Purplestraw usually has given higher average yields than any other wheat in South Carolina, Georgia, Alabama, and Mississippi. It also has given high comparative yields in Arkansas, North Carolina, and northeastern Virginia. The yields of Purplestraw usually have been higher than those of Fultz and Red May in these sections, and as high or higher than those of Fulcaster. As the latter is a bearded variety, it is less popular than Purplestraw in the southern areas. Purplestraw is of good milling and baking quality, being equal to any of the varieties thus far discussed.

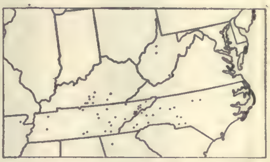


FIG. 7.—Outline map of a portion of the east-central United States, showing where Rice wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 30,900 acres.

CLIMAX.

Climax (Jones Climax) is known also as Grecian, Pennsylvania, Wilson, and Wilson Special. A variety known as Celebrated K. B. No. 2 is practically identical with Climax, but the heads of Climax are somewhat more nodding. These two wheats are here considered as being the same. Climax is later and taller than most of the varieties thus far discussed, and the kernels are longer. The heads of Climax are long, tapering, loose, and nodding. (Fig. 11, B.) The straw is white and the kernels soft.

The Celebrated K. B. No. 2 was found in a field of Longberry Clawson wheat belonging to the Knight & Bostwick Seed Co., Rochester, N. Y., in 1898. It was distributed in 1902 but is not known to be grown now under that name. This wheat has been distributed more recently as Jones Climax, and under this name it is grown in several Eastern and Southern States. It is not an important variety, however, as only about 16,000 acres were grown in the United States in 1919.

This variety has not given high comparative yields in any trials and could be displaced profitably by other varieties. The milling and baking value of Climax has not been determined.

LEAP.

Leap (Leap's Prolific) is known also as Hastings Prolific, Woods Prolific, and Woolf. It has rather wide but tapering, open, nodding heads. Brownish stripes on the chaff give it a yellowish appearance (Fig. 4, A). The plants are early and of medium height. The straw is white and the red kernels are midsized and soft.

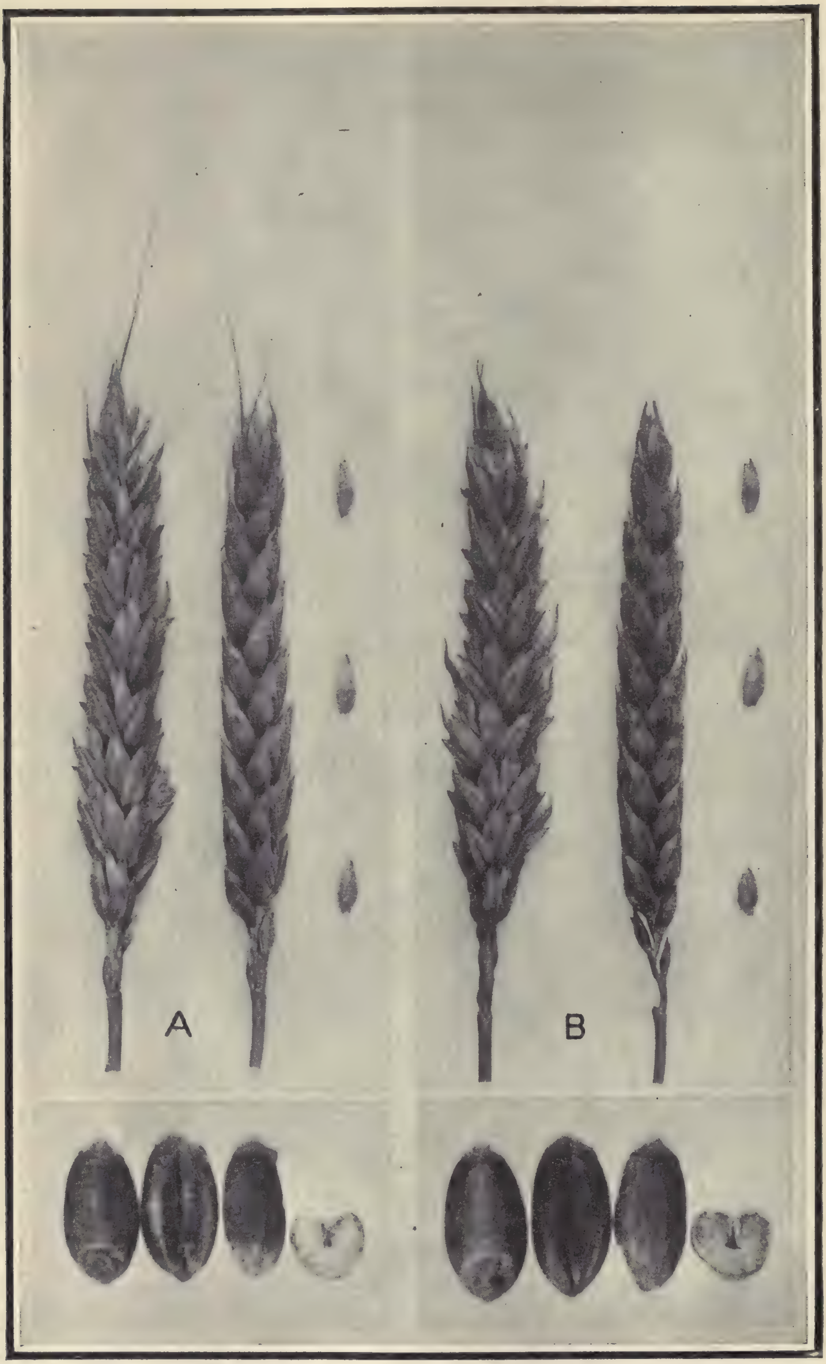


FIG. 8.—Heads, chaff, and kernels of Flint (*A*) and Purplestraw (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

Leap originated from a plant found in 1901 in a field of Mediterranean growing on the farm of J. S. Leap in Virginia. It was distributed about 1905 by T. W. Wood & Sons, seedsmen, of Richmond, Va. The variety rapidly became important, principally in Virginia and North Carolina, but it is grown also in 16 other Eastern and Southern States. More than 500,000 acres were grown in 1919, distributed as shown on the accompanying map (Fig. 12).

Leap has given good yields in Virginia and North Carolina. It is one of the good varieties in these States, but has not outyielded all other varieties. In comparative experiments Purplestraw and Fulcaster, the latter a bearded variety, have yielded as well as or better than Leap. Lack of beards may explain some of its popularity in some sections. Leap should be grown only in localities where it outyields Purplestraw, Fultz, and Red May. In States other than Virginia and North Carolina, Leap generally is outyielded by one or more varieties. Its milling and baking quality is good, being about equal to the varieties previously discussed.

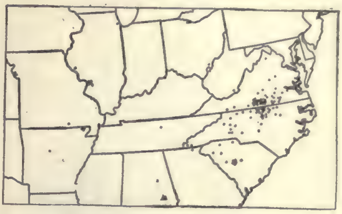


FIG. 9.—Outline map of a portion of the east-central United States, snowing where Flint wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 97,200 acres.

PROSPERITY.

Prosperity (American Bronze) is known also as Dutch, Hundred Mark, International No. 8, Invincible, Michigan Red, No Name, No. 8, Red Victory, Silver Chaff, Twentieth Century, and Zinn's Golden. This wheat differs from Leap in having longer and wider, more nodding and less tapering heads (Fig. 13, B). Like Leap, it has yellowish chaff. Just before maturity the stems of Prosperity wheat are covered with a white waxy coating, easily rubbed off. The kernels are midsized and angular.

This variety was originated by A. N. Jones, of Newark, N. Y., and is said to be the result of a cross between Martin Amber (a white wheat) and Fultz. Mr. Jones called it No. 8, but later named it American Bronze. It was first distributed by Peter Henderson & Co., seedsmen, of New York City. The variety is grown in Indiana, Michigan, Missouri, New York, Ohio, Pennsylvania, and West Virginia, although not important in any of these States. About 46,000 acres of Prosperity wheat were grown in the United States in 1919. Its distribution then is shown on the map (Fig. 14).

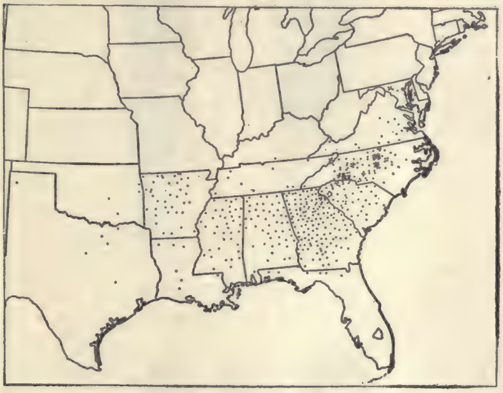


FIG. 10.—Outline map of the southeastern United States, showing where Purplestraw wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 273,800 acres.

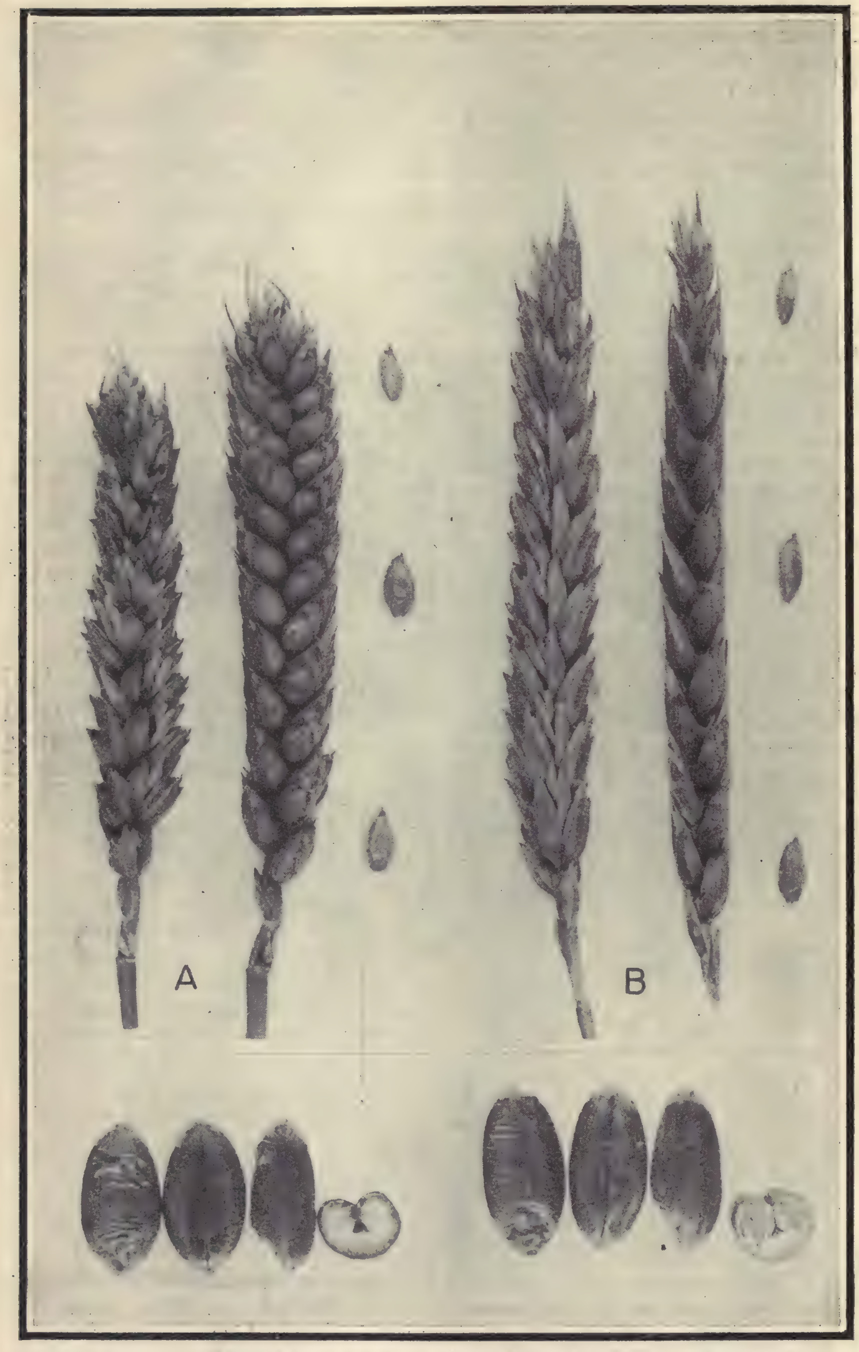


FIG. 11.—Heads, chaff, and kernels of Red Russian (*A*) and Climax (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

Prosperity has shown high comparative yields only in New York, where it is one of the highest yielding soft red winter varieties. In that State, however, the common white wheats are more productive. Prosperity is of rather poor milling and baking quality, being considerably inferior to Fultz.

FORWARD.

Forward is very similar to Prosperity. It originated from a beardless plant found growing in a field of Fulcaster. The selection was made and the strain has been developed in connection with the experiments in cereal breeding conducted by the Cornell University Agricultural Experiment Station in cooperation with the United States Bureau of Plant Industry. After it had produced good yields at that station it was distributed first in the fall of 1920. Forward is grown on a limited acreage in New York. It appears to be the highest yielding variety of soft red winter wheat in New York and should be grown in preference to other varieties of that class. Nothing is known concerning its milling and baking quality.

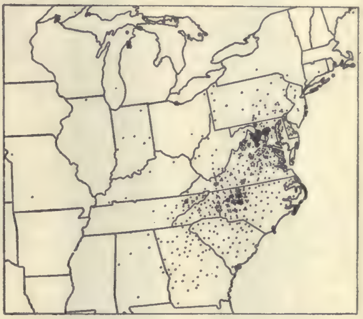


Fig. 12.—Outline map of a portion of the eastern United States, showing where Leap wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 513,100 acres.

HARVEST QUEEN.

Harvest Queen is known also as Black Sea, Canadian, Canadian Fife, Imported Scotch, Italian Wonder, Kansas Queen, May Queen, New 100, Oregon Red, Prairie Queen, Red Cross, Salzer's Prizetaker, Virginia Reel, and Winter Queen. This wheat differs from those previously discussed in having compact, nearly erect, square or slightly club-shaped heads (Fig. 13, A). The plants are tall and midseason in maturity. The straw is white and strong. The kernels are dull red, soft, and midsized.

Harvest Queen is an old variety, usually known as Black Sea, Oregon Red, and Red Cross. A plant of this wheat was found in a field of another variety by E. S. Marshall, of De Soto, Kans., in 1895. It was increased and named Harvest Queen in 1897. The variety was distributed by Mr. Marshall in the vicinity of its origin and also by seed firms in other localities. A Harvest Queen wheat having white grains was formerly grown in this country, but apparently has passed out of cultivation.

Harvest Queen (including synonymous varieties) is now an important variety in eastern Kansas, northwestern Missouri, and northern Oklahoma. A considerable acreage is grown also in Illinois. It is seventh in importance among the soft red winter wheats. About 1,000,000 acres of Harvest Queen wheat were grown in the United States in 1919, distributed as shown on the accompanying map (Fig. 15).

Harvest Queen is one of the highest yielding varieties in northeastern Kansas and the adjoining section of Missouri, where it usually

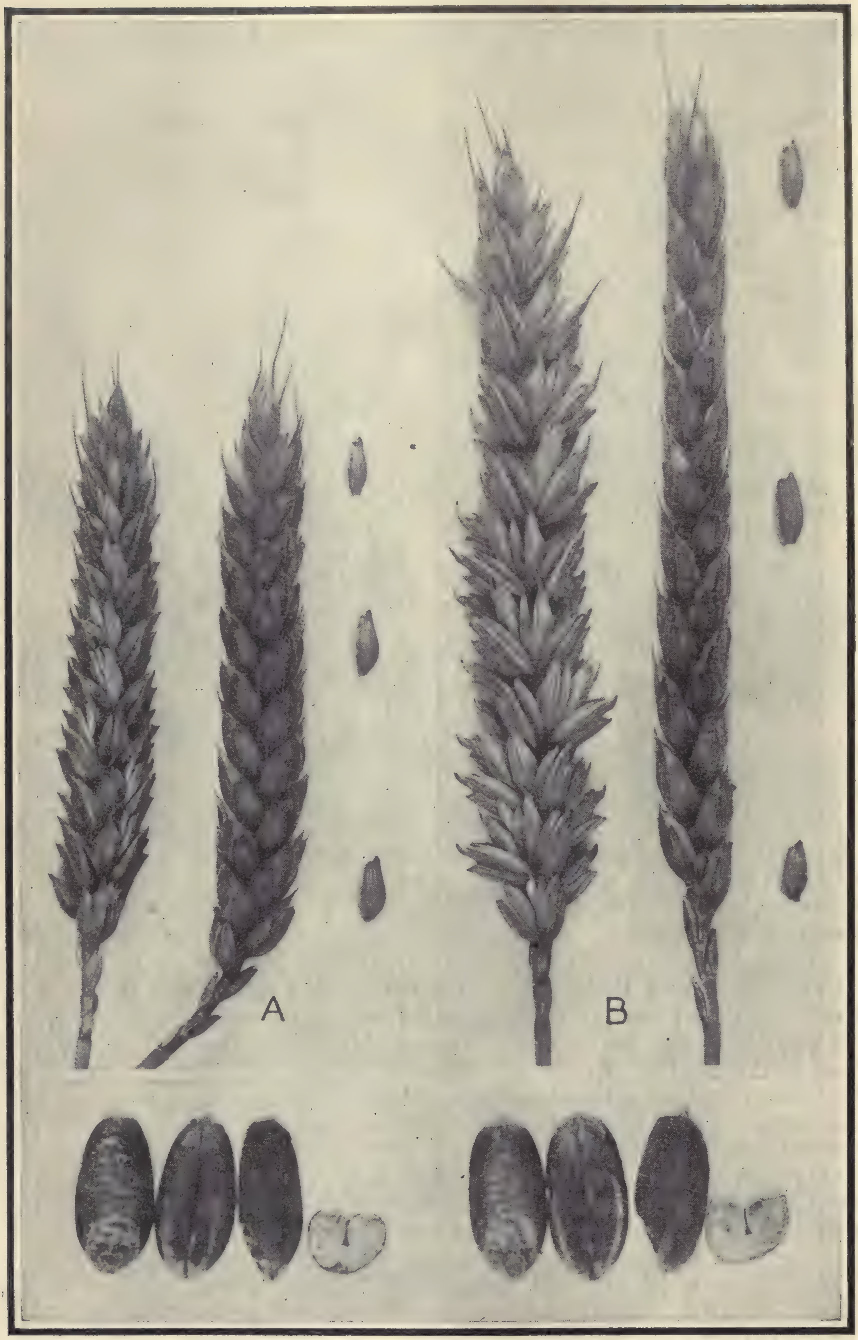


FIG. 13.—Heads, chaff, and kernels of Harvest Queen (*A*) and Prosperity (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

outyields Fulcaster, Fultz, Currell, and the hard red winter wheat varieties. It usually is outyielded by Fulcaster and Mediterranean in southern Kansas and northern Oklahoma, and by Fulcaster and other varieties in eastern Missouri and in Illinois. In Illinois and Indiana there has recently appeared the rosette disease of wheat (one of the foot-rot or take-all group), to which the Harvest Queen variety is very susceptible. A strain has been selected from the variety, however, which is not susceptible. Until this strain is available for distribution, Harvest Queen should not be grown in or near the areas where the disease occurs.

In milling and baking quality Harvest Queen is good, being nearly equal to the varieties previously discussed.

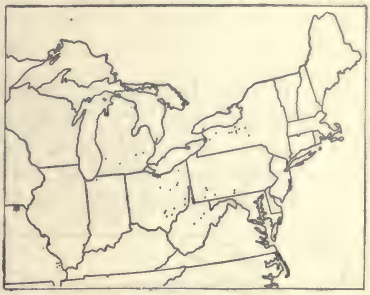


FIG. 14.—Outline map of a portion of the northeastern United States, showing where Prosperity wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 46,000 acres.

FULTZO-MEDITERRANEAN.

Fultzo-Mediterranean is known also as Club, Club Head, Columbia, Double Head, Duck Bill, Early Ontario, Economy, Farmers Pride, Flat Top, Four-Row Fultz, Harper, New Columbia, Scott's Squarehead, Squarehead, Square Top, and Stub Head. Fultzo-Mediterranean differs from all other varieties in this section in having erect, short, compact, decidedly clubbed heads. The heads (Fig. 2, B) resemble those of club wheat to some extent. The plants are midtall and midseason in maturity. The straw is purple and strong. The kernels are very similar to those of Fultz.

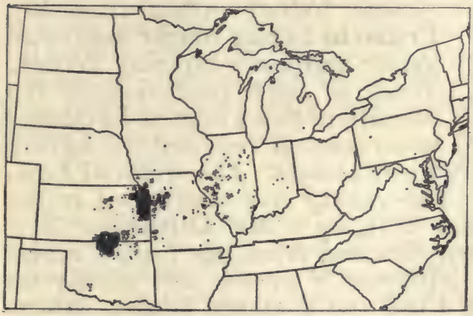


FIG. 15.—Outline map of a portion of the United States, showing where Harvest Queen wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 1,007,600 acres.

Under some of the names listed above the Fultzo-Mediterranean variety has been grown for many years, but its exact origin is not known. It has been grown as Columbia and New Columbia since 1893. The variety was first named and distributed as Fultzo-Mediterranean in 1898 by a seed company which claimed that the wheat was a cross between Fultz and Mediterranean. From the character of the wheat this origin is very improbable.

Fultzo-Mediterranean is grown now in at least 17 States in the eastern half of the United States but is not a leading variety in any of them. It is most important in Missouri, Illinois, and Indiana. About 287,000 acres of Fultzo-Mediterranean were grown in the United States in 1919. The distribution is shown in Figure 16.

Because of its strong stiff straw Fultzo-Mediterranean wheat is often grown on rich, wet, heavy, or bottom lands where other varieties are likely to lodge. It has given good yields in Kentucky, and to a less extent in other States under the above conditions. In general, this wheat has given lower yields than others grown in the same districts. It is somewhat inferior to Fultz in milling and baking quality.

BIG FRAME.

Big Frame has short, tapering, inclined heads. The plants are of midheight and are midseason in maturity. The straw is white. The kernels are midsized, soft, and rounded. The variety differs from Zimmerman in being later and in having more tapering heads.

Big Frame was grown in the Middle Western States many years ago, but the origin of the variety is not known. It was an important variety in Nebraska in the early nineties, but is grown there only in small areas at the present time. It formerly was one of the high-yielding wheats in that State, but it has been displaced almost entirely by hard winter varieties, which are more productive and of higher quality.

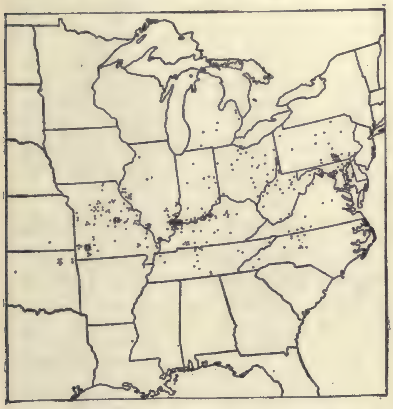


FIG. 16.—Outline map of a portion of the eastern United States, showing where Fultzo-Mediterranean wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 287,900 acres.

LOFTHOUSE.

Lofthouse (Winter La Salle and Winter Nellis) differs from Big Frame in having longer heads and longer and more tapering kernels. There is some confusion in the identity of this wheat, as Lofthouse sometimes is reported as having white kernels. The origin of Lofthouse is not definitely known. The variety was distributed in the vicinity of Paradise, Utah, about 1894, by a Mr. Lofthouse. The wheat was reported to have been obtained from the United States Department of Agriculture. Lofthouse is grown now mostly on dry lands in a few counties in Utah and southern Idaho. About 6,500 acres were reported in 1919.

This variety has not given high comparative yields in any experiments and should be replaced, therefore, by other varieties, such as Turkey, a hard red winter wheat. From the appearance of the kernels Lofthouse probably is equal of any of the varieties thus far discussed in milling and baking quality.

BUFFUM NO. 17.

Buffum No. 17 has longer heads than Lofthouse, is at least a week later, and is more winter hardy (Fig. 6, B). The kernels are somewhat harder than those of Lofthouse and most of the wheats so far discussed. Buffum No. 17 is one of the hardiest winter wheats known for the Great Plains area.

This variety originated from a plant found in a field of Turkey wheat by B. C. Buffum, of Worland, Wyo. After being increased it was distributed in 1912. It is grown now to a limited extent in Wyoming.

Buffum No. 17 wheat has given yields nearly equal to those of the best hard red winter varieties in Wyoming and northeastern Colorado. Because of its hardiness it is more successful than other varieties in some seasons. It is not sufficiently hardy, however, to withstand the most severe winters and therefore is less certain than spring wheat. It matures too late to be productive in some seasons. Buffum No. 17 wheat can be recommended only for limited areas in Wyoming, and even there its status is doubtful because of the competition of wheats of other classes. In milling and baking quality it is good, probably being equal to or slightly better than the varieties previously discussed.

MINHARDI.

Minhardi (Minnesota No. 1505) is similar to Big Frame except in having erect heads and in being extremely hardy. It is, perhaps, the hardiest winter wheat known. The straw is white and slender, but rather strong. This variety is the result of a cross between Odessa (a soft red winter wheat) and Turkey (a hard red winter wheat) made at the Minnesota Agricultural Experiment Station in 1902. After having been selected and tested for several years it was named and distributed to farmers in Minnesota about 1919. The Minhardi variety has not given high yields except in limited areas in Minnesota. Another variety of the same origin as Minhardi and named Minturki (Minnesota No. 1507) is nearly as hardy and is more productive and of better quality than Minhardi. Minturki, a bearded wheat of the hard red winter class, generally should be grown in preference to Minhardi. Minhardi is of higher milling and baking quality than most of the soft red winter wheats previously discussed.

RED RUSSIAN.

Red Russian (known also as Australian Club, Early Sunrise, Squarehead, German Red, Montana Deal, and Red Walla) matures extremely late. It has nearly erect, compact, clubbed heads (Fig. 11, A). The straw is white, thick, and strong and the leaves wide and dark green. The kernels are midlong but wide and quite soft. This wheat should not be confused with other varieties grown in the Central and Eastern States which also sometimes are called Red Russian.

The history of this variety is not known, but probably it is of European origin, as it greatly resembles the so-called "Squarehead" wheats of northern Europe in appearance and time of maturity.

Red Russian has been grown in Washington for at least 30 or 40 years. About 1890 it was introduced into the Palouse section of Washington and Idaho, where it is now of more importance than elsewhere. About 155,000 acres of Red Russian were grown in 1919 in four Northwestern States, as shown on the accompanying map (Fig. 17).

Because of its late maturity Red Russian is outyielded by several other varieties in Idaho and eastern Washington, but in the cool, humid sections of western Washington it is the most productive wheat. Outside of this section of Washington, where it sometimes gives very high yields, it should be displaced by better varieties of club, common white, or hard red winter wheats.

Red Russian is probably the poorest of the soft red winter wheats in milling and baking quality. In the Federal Grain Standards it is placed in the Western Red subclass because of its low market value.

SOL.

Sol (Sun) is nearly identical with Red Russian, but the heads are slightly less clubbed and the leaves are longer, wider, and darker colored. This variety originated at the Svalof Plant Breeding Station in Sweden, apparently having been selected from a natural cross between two varieties. It was distributed in Sweden in 1911. In recent years the Sol variety had been distributed in the United States by Charles H. Lilly & Co., seedsmen, of Seattle, Wash., and is grown sparingly in the Puget Sound district of Washington and in California. Sol is very similar to Russian in yield and adaptation and should be grown only where that variety is adapted. As the kernels of the two varieties are practically identical, they are probably alike in milling and baking quality.

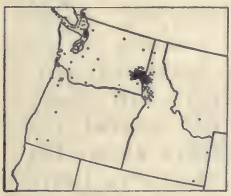


FIG. 17.—Outline map of the Pacific Northwest, showing where Red Russian wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 154,900 acres.

SQUAREHEAD.

Squarehead (English Squarehead, Big English, and Clanfield) is practically identical with Red Russian except in being slightly taller and in having slightly longer and less clubbed heads. This is an old English variety which was brought to this country by Richard Clanfield, of Ballston, Oreg., in 1908. It is grown to a slight extent in the Willamette Valley of Oregon. Squarehead is fairly productive under the cool humid conditions of Willamette Valley, but probably will not yield as well as several varieties of common white wheat. The milling and baking quality of Squarehead apparently does not differ from that of Red Russian.

Section 2.—HEADS BEARDLESS; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED.

This section is composed of 21 recognized varieties, several of which are made up of a number of so-called varieties which can not be distinguished one from another. Some of the most important soft red winter wheats are included in this section.

POOLE.

Poole is known also as Bluestem, California Red, Gill, Harvest King, Hedge Prolific, Hundred Mark, Hydro Prolific, Mortgage

Lifter, Kentucky Bluestem, Nissley or Nissley's Hybrid, Ocean Wave, Oregon Red Chaff, Red or California, Red Amber, Red Chaff, Red Fultz, Red King, Red Russell, Royal Red Clawson, Sweet Water Valley, Wagner, and Winter King. It also occurs as a mixture in a wheat called Beechwood or Beechwood Hybrid.

Poole has beardless heads with brown chaff and soft red kernels. The heads are long, wide, flattened, and very nodding (Fig. 18, B). The variety is midseason in maturity. The straw is purple and of medium strength and height. The kernels are midlong and somewhat cylindrical in shape.

The origin of Poole has not been determined, but it has been an important variety in Ohio and Indiana for nearly 40 years. The various names listed above have been applied to it from time to time by growers and seedsmen under the pretense or supposition of having a new variety. A considerable proportion of Poole is grown as Harvest King.

Poole is now fourth in importance among the soft red winter wheats. About 2,450,000 acres were grown in the United States in 1919, nearly half of which was in Ohio. The other States producing large acreages of Poole are Indiana, Missouri, Illinois, and Kentucky. Its distribution in the United States is shown on the accompanying map (Fig. 19), which indicates that it is grown in at least 21 States.

Poole is adapted in general to a large area in the Eastern States, but principally in the eastern half of the Corn Belt. In Ohio it outyields all soft red winter wheats except three new varieties—Gladden, Trumbull, and Portage—the last of which was selected from Poole. Although usually outyielded by some bearded varieties it is apparently the best beardless variety in portions of Indiana, Illinois, Missouri, and Kentucky. Poole is among the high-yielding varieties of the beardless soft red winter wheats in most of the Eastern States.

In milling and baking quality Poole is superior to many of the soft red winter wheats and is fully equal to any of the varieties thus far discussed.

PORTAGE.

Portage can scarcely be distinguished from Poole. It was selected from Poole at the Ohio Agricultural Experiment Station. It was distributed in Ohio several years ago and is grown now in that State as well as in New York and Pennsylvania. Portage has given higher yields than Poole in all parts of Ohio and therefore should be grown in preference to the latter variety. In some parts of Ohio Portage has not given as high yields as the Gladden and Trumbull varieties but has surpassed them in other parts.

In milling and baking quality Portage appears to be somewhat superior to Poole.

RUSSIAN RED.

Russian Red (or Red Russian) can scarcely be distinguished from Poole, differing only in a few minor head characters. This variety is reported to have been introduced from Russia by the American Seed Co., of Rochester, N. Y., apparently during the eighties. It later was distributed also by several other seed companies. The

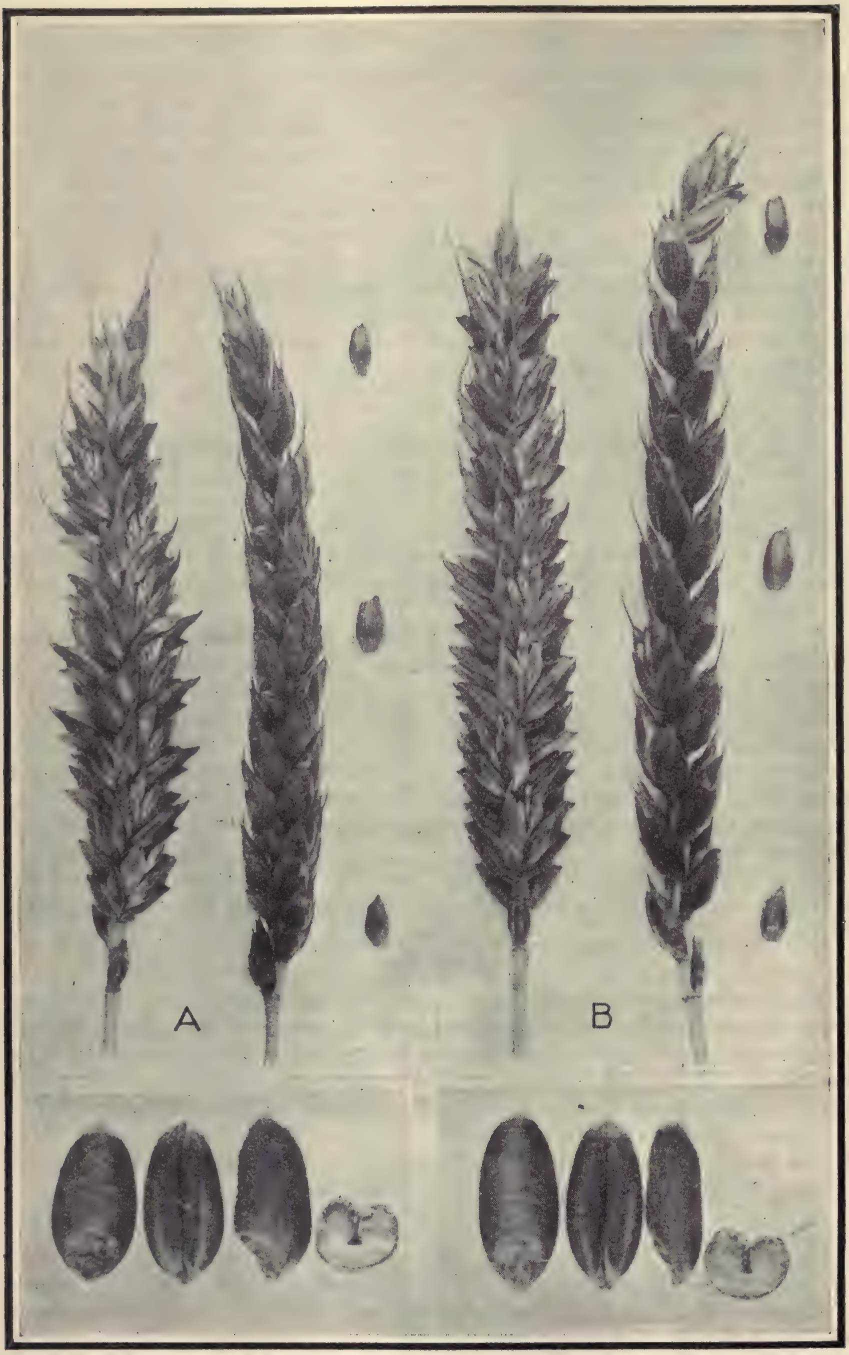


FIG. 18.—Heads, chaff, and kernels of Currell (*A*) and Poole (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

wheat is grown rather widely in about 14 States. About 170,000 acres were grown in 1919, distributed as shown on the accompanying map (Fig. 20.) The leading States in the production of Russian Red are Indiana, Ohio, and Illinois. Owing to the confusion of the names, Russian Red and Red Russian, both of which are used for several varieties of wheat, the determination of the exact distribution of the above wheat is difficult.

The yields of Russian Red have been less than those of several other varieties in the Corn Belt. The variety could be displaced generally with profit by other wheats. Russian Red apparently is not superior to Poole in milling and baking quality.

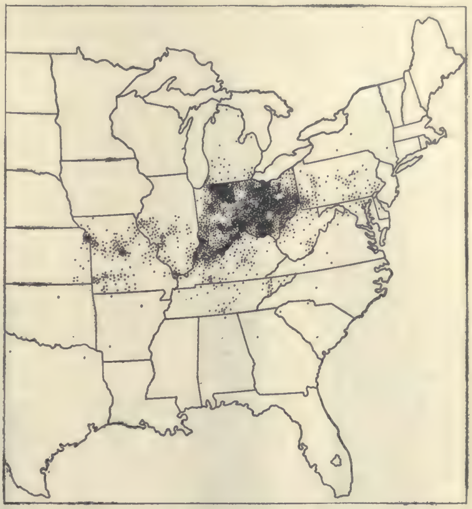


FIG. 19.—Outline map of the eastern United States, showing where Poole wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 2,453,400 acres.

RED MAY.

Red May is known also as Canadian Hybrid, Early Harvest, Early May, Early Ripe, Enterprise, Jones Longberry, May, Michigan Amber, Michigan Wonder, Orange, Pride of Indiana, Red Amber, Red Cross, Red Republic, and Republican Red. This wheat differs from Poole in being earlier and in having more erect heads, wider chaff, and wider and more angular kernels (Fig. 21, B).

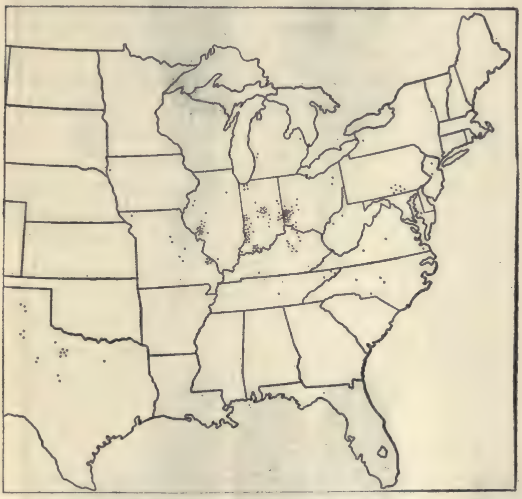


FIG. 20.—Outline map of the eastern United States, showing where Russian Red wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 172,000 acres.

Red May is a very old variety of wheat. It has been recorded as being identical with the Red Lammas or Yellow Lammas wheat which was grown in Europe during the seventeenth century. Various other histories of the variety have been given, but it seems certain that Red May wheat has been grown in the United States for nearly 100 years.

Red May wheat, including the synonymous varieties, is now grown in about 25 States in the eastern half of the United States. It is

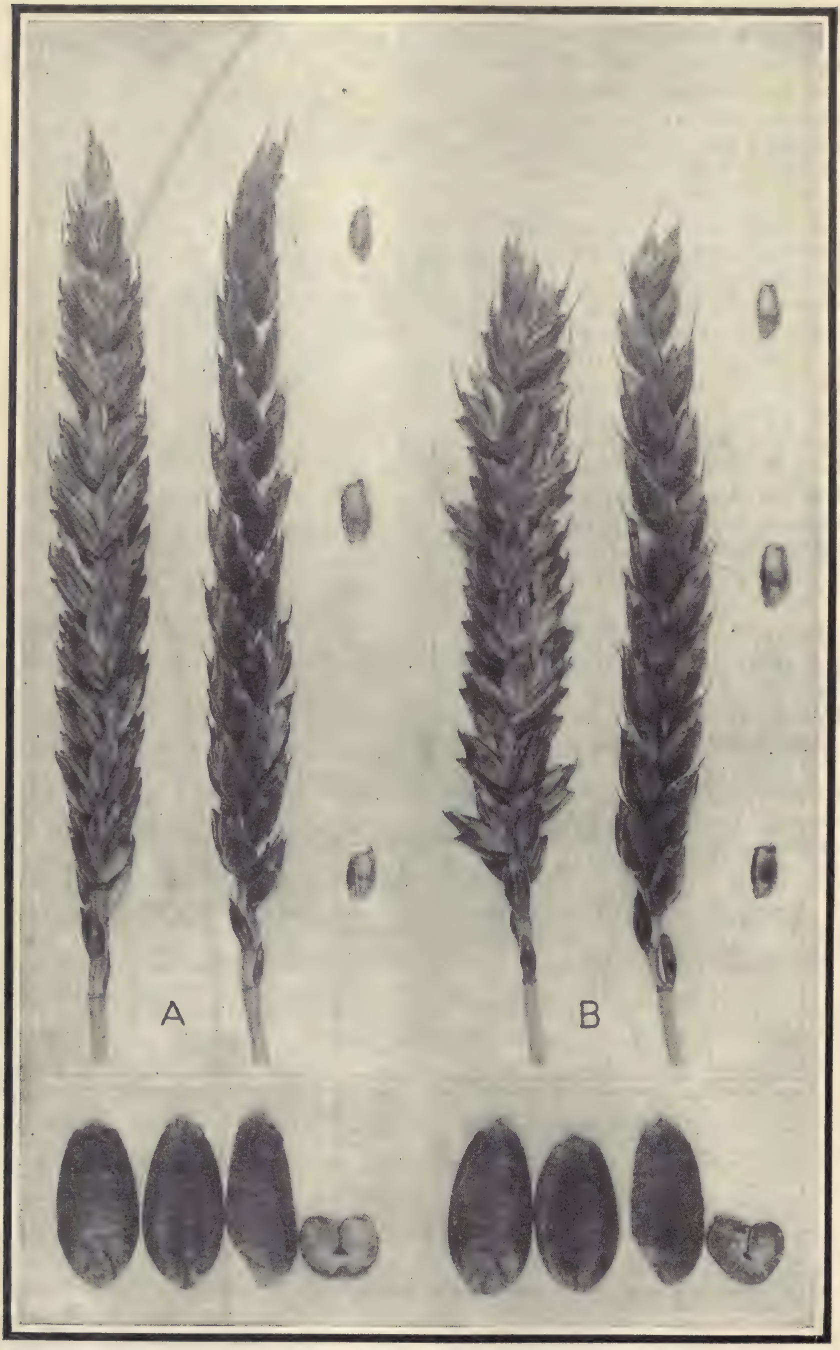


FIG. 21.—Heads, chaff, and kernels of China (*A*) and Red May (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

most important in Missouri, Kansas, Indiana, Illinois, and Arkansas. About 1,165,000 acres of Red May wheat were grown in the United States in 1919, distributed as shown on the accompanying map (Fig. 22). It is fifth in importance among the soft red winter wheats. As the name Red May is badly confused with other varietal names, especially Flint, the exact determination of the distribution of the variety is difficult.

Red May is one of the best varieties in the southern Cotton Belt, but usually is outyielded by Purplestraw and Fulcaster. Under such names as Michigan Wonder and Early Ripe, the Red May is a productive variety in parts of Indiana and Missouri. In Missouri, however, the Fulcaster variety gives higher yields. Although a good wheat for general growing over a large area, Red May could be displaced by higher yielding varieties in most of the sections where it is grown now.

In milling and baking quality Red May is fair, being somewhat inferior to Fultz and similar wheats.

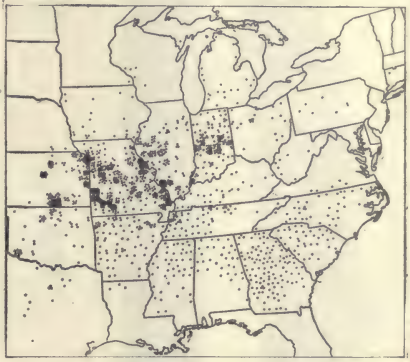


FIG. 22.—Outline map of the eastern United States, showing where Red May wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 1,165,900 acres.

ILLINI CHIEF.

Illini Chief (Early Carlyle and Finley) differs from Red May in being taller and later. The heads of the two varieties are practically identical, although Illini Chief contains mixtures of other forms. Illini Chief has shown considerable resistance to Hessian fly injury. The origin of Illini Chief is not known, but it formerly was grown in Ohio as Early Carlyle and later in Illinois as Finley. It was named and distributed as Illini Chief in 1915 by E. L. Gillham, of Edwardsville, Ill., who called attention to its resistance to Hessian fly.

The variety is now grown to a limited extent in Illinois, Kansas, Missouri, and Ohio. Limited tests of Illini Chief have not shown it to be a high-yielding variety except when Hessian fly injury is severe on other varieties. This wheat should be grown only in order to avoid this injury, as in general other varieties give higher yields. In milling and baking quality Illini Chief probably does not differ from Red May.

RED CLAWSON (EARLY RED CLAWSON).

Red Clawson (Zellar's Valley) differs from Red May in being later and in having slightly longer and more clubbed heads and longer kernels (Fig. 23, A). This variety was originated in 1888 as the result of a cross between Clawson (a white common wheat) and Golden Cross made by A. N. Jones, of Newark, N. Y. It was distributed first by Peter Henderson & Co., seedsmen, of New York City. Red Clawson is now grown in 15 States. It is most important

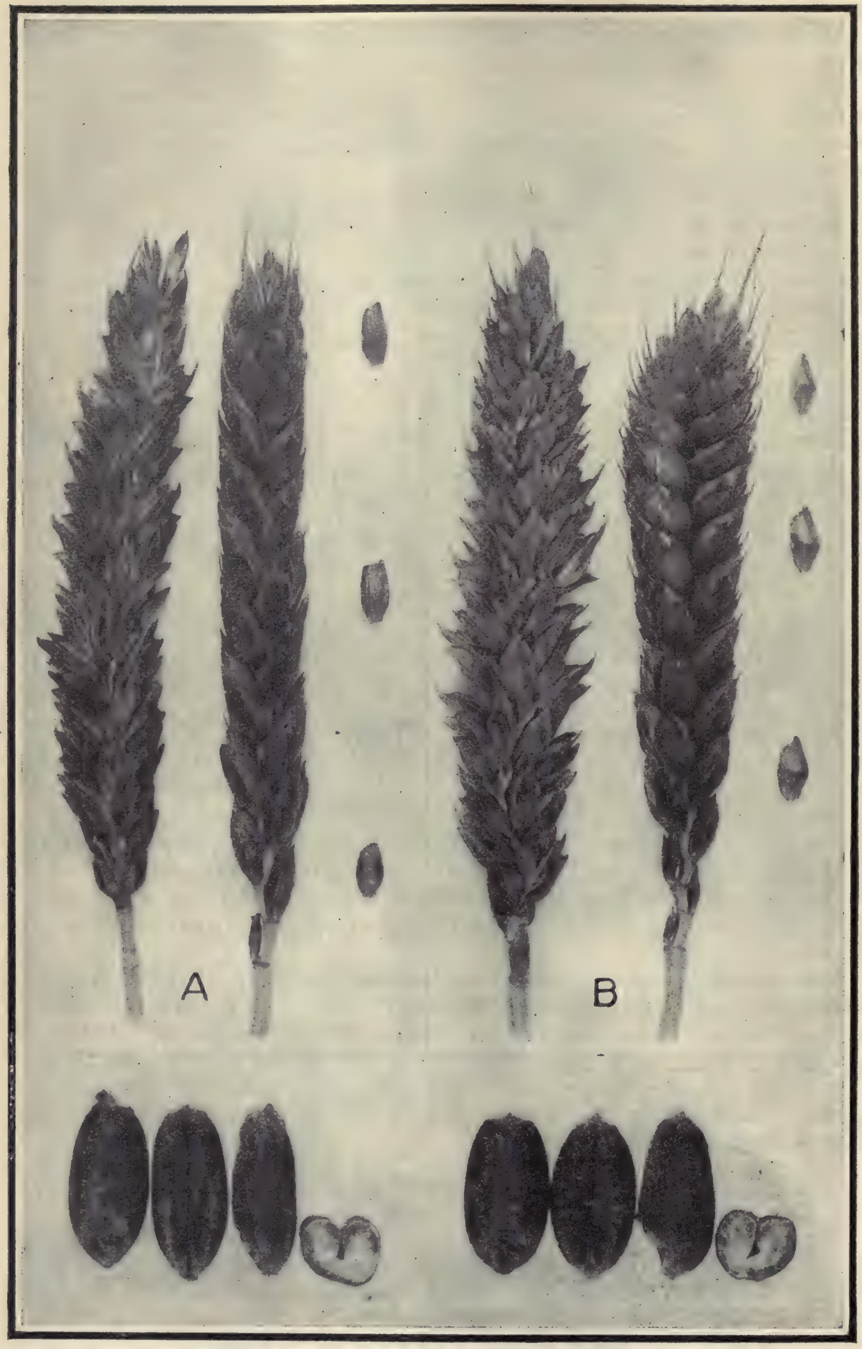


FIG. 23.—Heads, chaff, and kernels of Red Clawson (*A*) and Rochester (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

in Michigan and Ohio. About 80,000 acres of Red Clawson were grown in the United States in 1919, distributed as is shown on the accompanying map (Fig. 24).

Red Clawson is not one of the higher yielding varieties in any section of the United States. It should be displaced by more productive wheats. It is of rather poor milling and baking quality.

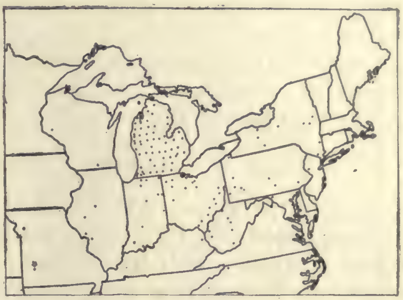


FIG. 24.—Outline map of the northeastern United States, showing where Red Clawson wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 80,900 acres.

ROCHESTER (ROCHESTER RED).

Rochester (Pride of the Valley and Shepherd's Tennessee Fultz) has erect, compact, very clubbed heads (Fig. 23, B) which easily distinguish it from Red May and Red Clawson. Nothing is known concerning the origin of the variety, but the seed was offered for sale as early as 1891 by a seed company in New York. Rochester wheat is now grown sparingly in New Jersey and New York.

Rochester is not among the highest yielding varieties in any of the sections where it has been grown. Apparently it should be displaced by more productive varieties. Nothing is known concerning its milling and baking qualities.

CHINA.

China (Bluestem, Lebanon Valley, Mortgage Lifter, and Pennsylvania Bluestem) (Fig. 21, A) is taller and later and has weaker straw and more slender and tapering heads than Red May. The kernels of China are tapering and slightly curved.

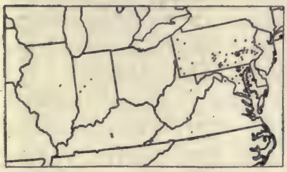


FIG. 25.—Outline map of a portion of the eastern United States, showing where China wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 63,900 acres.

Several stories concerning the introduction of China have been recorded, but the most authentic history indicates that the wheat was brought from China about 1845 by Hon. Caleb Cushing, United States Minister to China. The wheat was grown and distributed by a Mr. Caverns and has since become rather extensively grown. It is found now in at least eight States and is of most importance in Pennsylvania and Maryland. About 64,000 acres of China were grown in 1919, distributed as shown on the accompanying map (Fig. 25).

China is one of the highest yielding varieties in eastern Maryland and southeastern Pennsylvania. It is outyielded slightly by various strains of Fulcaster, a bearded wheat, and is little, if any, better than Currell. In Pennsylvania, Dawson, a white wheat, has outyielded China, but it is of lower commercial value than China.

In milling and baking value China is good, being nearly equal to most of the other soft red winter wheats previously discussed.

WHEEDLING.

Wheedling differs from China chiefly in being shorter and in having more erect heads. It was originated about 1890 from heads selected from a field of wheat in Indiana by Louis Wheedling. The wheat was increased, until it now is grown in several counties in northern Indiana. About 11,000 acres were grown in 1919.

Wheedling is not a leading variety in the sections where it is grown. Apparently it could be displaced by more productive varieties, such as Poole, Red May, Fultz, or Red Rock. Nothing is known concerning the milling and baking quality of Wheedling.

CURRELL (CURRELL'S PROLIFIC).

Currell is known also as Gill, Golden Chaff, Pearl Prolific, Red Odessa, Red Prolific, and Tennessee Prolific. It differs from the other wheats which have brown chaff and purple straw so far discussed in this section in having quite slender heads (Fig. 18, A). It is earlier and shorter than China. The straw usually is purple, but sometimes the color fails to develop.

This variety originated from three heads found in a field of Fultz, in Virginia, by W. E. Currell in 1881. It was first sold for seed in 1884. About 645,000 acres were grown in at least 18 States in 1919, as shown on the accompanying map (Fig. 26). It is most important in Missouri, Kansas, Maryland, Oklahoma, and Kentucky.

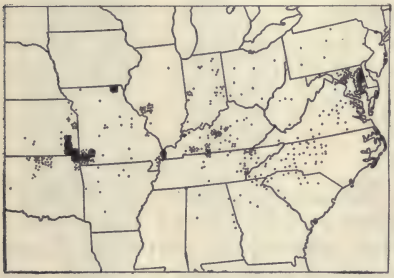


FIG. 26.—Outline map of the east-central United States, showing where Currell wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 645,000 acres.

Currell is among the best varieties in Maryland, Pennsylvania, New Jersey, and Virginia. It also is a productive variety in western Kentucky and in southeastern Kansas and the adjoining section of southwestern Missouri.

In the sections just mentioned Currell could further displace some of the less productive varieties. The bearded variety, Fulcaster, is somewhat more productive than Currell in Maryland, Pennsylvania, and Virginia.

Currell, although good, is apparently slightly inferior to China in milling and baking quality.

RED WAVE.

Red Wave is known also as Advance, Indiana Red Wave, Jones Red Wave, Old Dutch, Red Chaff, Red Ivory, Red Wafer, Ruble, Rust Proof, Waif, Waverly, and Worlds Fair. It differs from the varieties previously discussed in having white or yellow instead of purple straw. The heads are long, wide, and quite nodding (Fig. 27, A). The chaff is of a light-brown color. Red Wave and Poole appear very similar in the field except that Poole has purple straw and slightly darker chaff.

Red Wave was originated by A. N. Jones, of Le Roy, N. Y., in 1906, by crossing Red Clawson with an unnamed crossbred wheat.

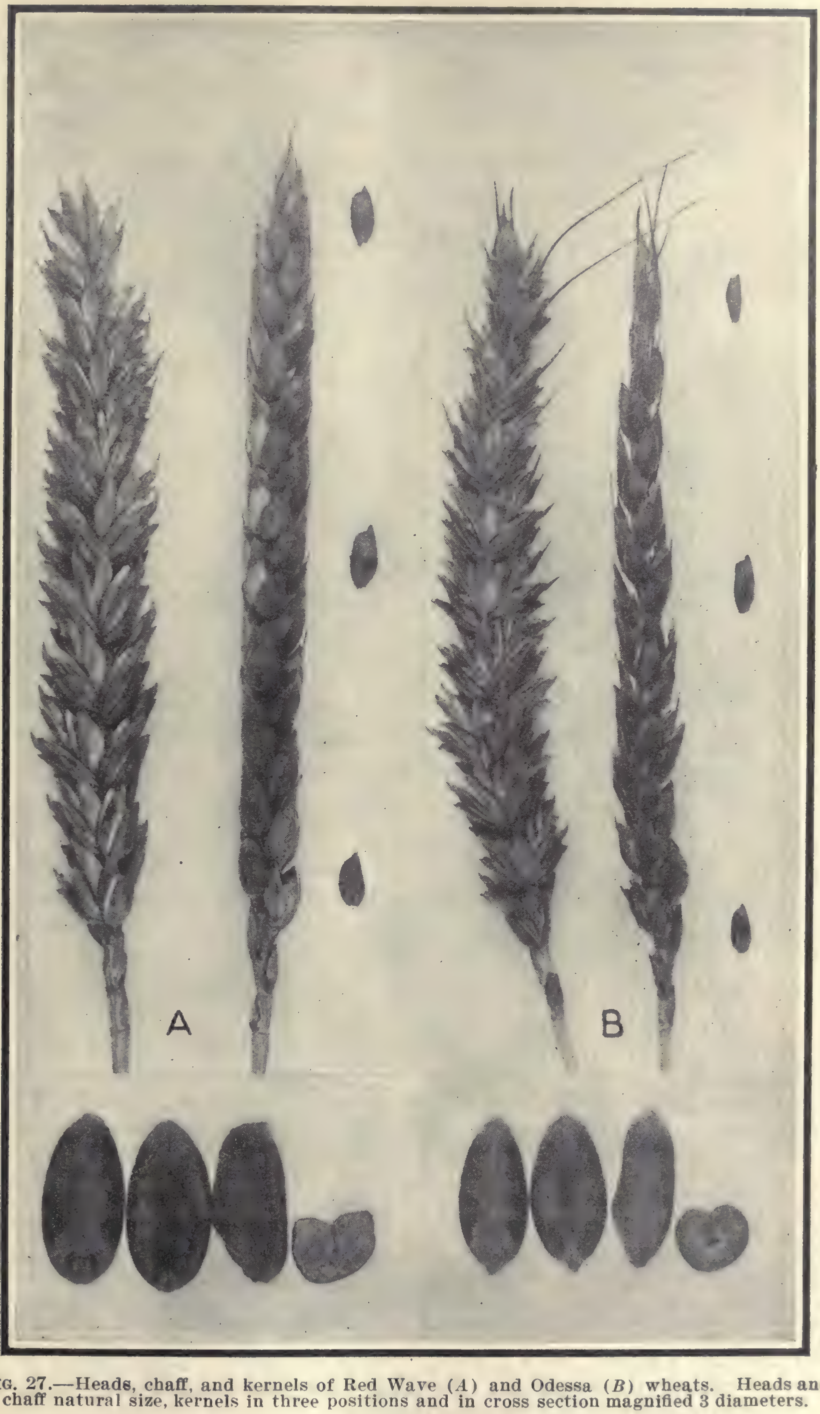


Fig. 27.—Heads, chaff, and kernels of Red Wave (*A*) and Odessa (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

It rapidly became popular, until it is now sixth in importance among the soft red winter wheats. About 1,132,000 acres of Red Wave wheat were grown in the United States in 1919. It is found in 22 States but is most important in Indiana, Ohio, Illinois, Pennsylvania, and Missouri. The distribution of Red Wave is shown on the accompanying map (Fig. 28).

Red Wave is among the more productive wheats in parts of Indiana, Missouri, Ohio, Pennsylvania, and Illinois, but is the best variety in only a few localities. In general, other varieties, such as Fulcaster and Poole, have given higher yields than Red Wave, so that in many sections more productive varieties should displace it.

Red Wave is considerably inferior in milling and baking quality to such varieties of soft red winter wheat as Fultz, Poole, and Fulcaster.

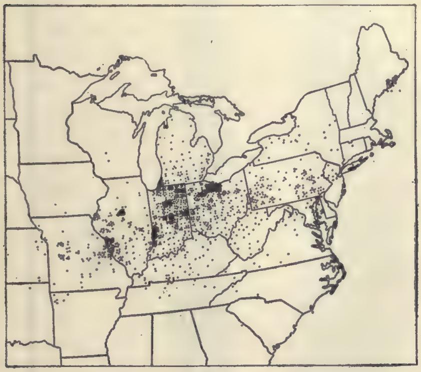


FIG. 28.—Outline map of a portion of the United States, showing where Red Wave wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 1,132,400 acres.

FLEMING.

Fleming (Russian Club and Winter Club) differs from Red Wave only in being slightly later and in having a somewhat narrower and less nodding head. This wheat was obtained from Russia by a Mr. Fleming, of Forsyth, Mont., who named it Russian Club and distributed the wheat in his vicinity. A limited acreage of the variety is now grown in Rosebud County, Mont. Fleming apparently is less hardy and productive than Turkey, a hard red winter wheat, and should be displaced by that variety. It can not compete with the hard red spring and hard red winter wheats in central and eastern Montana, but nothing is known concerning its behavior in other States. The milling and baking quality of Fleming has not been determined.

PETERSON (LARS PETERSON).

Peterson differs from Red Wave in being slightly taller and in having longer heads. The origin of the variety is not known, but it has been grown in Navajo County, Ariz., for several years. It is found now only in that county and is decreasing in importance there. Although Peterson has been fairly productive on the dry lands in the locality in which it is grown, it is now being and should be displaced there by more productive wheats of other classes.

HOMER.

Homer differs from Red Wave in having a less nodding head. The origin of this wheat is not known, although it has been grown in Chatham County, N. C., for 10 years or more. Apparently it is grown only in that county. Nothing is known concerning its productivity or milling and baking quality.

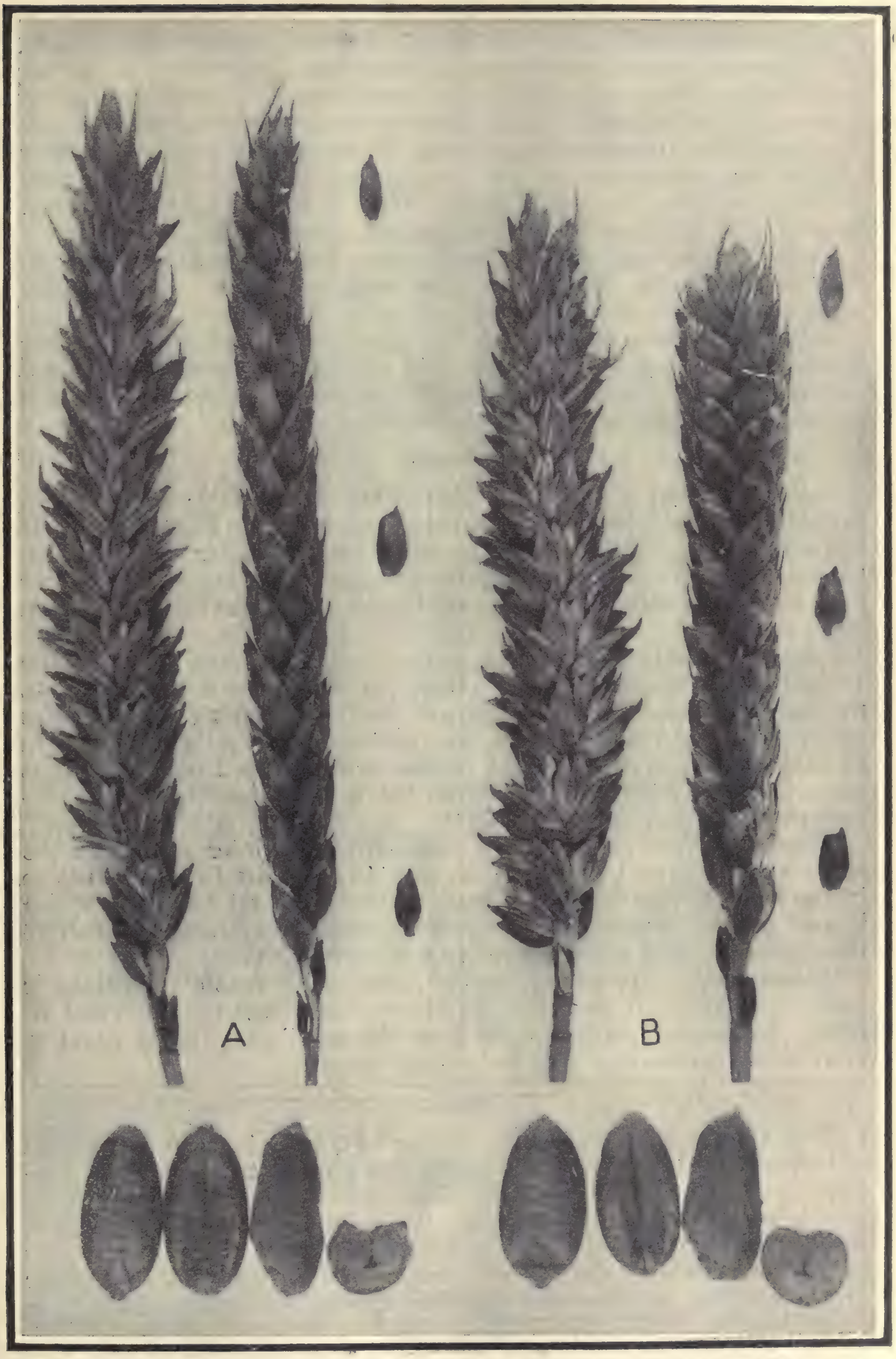


FIG. 29.—Heads, chaff, and kernels of Rupert (*A*) and Rural New Yorker No. 6 (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section, magnified 3 diameters.

RUPERT (RUPERT'S GIANT).

Rupert (known also as Gold Medal, Hartzel, Haskell, Red Hassel, Red Haskell, Ruck, and Woods) differs from Red Wave in having heads which are thicker at the tip, sometimes making them slightly clubbed (Fig. 29, A). The tip beards on the heads of Rupert also are longer than those on Red Wave. The origin of Rupert is rather obscure, but it appears to have been known first as Woods, which is reported to have originated from a head found in a field of wheat belonging to William Woods, of Talbott, Tenn.

Under the several names listed above Rupert is grown now in Kansas, Kentucky, Michigan, Ohio, and Tennessee. About 14,000 acres were grown in 1919.

Little is known concerning the productivity of Rupert. Apparently it does not outyield several of the more popular soft red winter varieties. Doubtless much of the present acreage of Rupert could be sown profitably to other wheats.

ODESSA.

Odessa (Grass) differs from Red Wave chiefly in having slender, tapering, inclined heads and in being much later (Fig. 27, B). It has white straw. The kernels are rather small, slender, and rounded. Odessa also is a very winter-hardy wheat and apparently is hardier than any of the soft red winter varieties except Minhardi and Buffum No. 17.

Odessa probably is of Russian origin, but it has been grown in the United States for nearly 60 years. It was grown in Minnesota during the sixties and in California and Utah during the seventies and eighties. In 1919 Odessa was grown on about 54,000 acres in 13 States. The distribution of Odessa is shown in Figure 30. It is not a leading variety in any region but is most important in southeastern Idaho and northern Utah.

Odessa can not compete with other soft red winter wheats in the eastern half of the United States, and it is too late to be productive in the Central and Northern States. In Utah and Idaho hard red winter and white common varieties in general are more productive than Odessa. The variety should be discontinued.

Odessa has a soft kernel, which under unfavorable conditions is quite shrunken. It therefore produces a medium or low yield of flour. In baking quality of the flour Odessa is good, being equal to most other varieties of soft red winter wheat.

RESACA.

Resaca (Red Resaca) is very similar to Odessa in head and kernel characters. It is earlier than Odessa, has purple straw, and will produce a crop from spring sowing. Resaca is thus a true spring wheat which is grown from fall sowing. Its origin is not known. It was introduced into Burnet County, Tex., over 30 years ago and is now grown there to a limited extent. Even there it yields less than other soft red winter varieties and therefore should be discontinued.

GOLD DROP.

Gold Drop (known also as Littleton) differs from Red Wave and other wheats in this section in being very early and in having short tapering heads. This wheat apparently is the old Golden Drop variety originated in England in 1834. It has been grown in this country for 80 years, but at present is found only in Arkansas, Missouri, Pennsylvania, and Tennessee. Only a few hundred acres are grown. The variety apparently is less productive than those commonly grown in the States named.

RURAL NEW YORKER NO. 6.

Rural New Yorker No. 6 (known also as Burtaker, No. 6, Red Hussar, and Twentieth Century) differs from Red Wave in having nearly erect, compact, clubbed heads (Fig. 29, B). The straw is white and thick. This variety is reported to have originated from a hybrid between Martin (Martin Amber or Armstrong), a white common wheat, and a plant of rye. The cross was made in 1883 by Elbert S. Carman, editor of the Rural New Yorker. The wheat was first offered for sale in 1894. It is grown rather sparingly in Michigan, New York, and Ohio. The names applied to it are confused with those of several other wheats, so an accurate determination of the distribution of this variety is not possible.

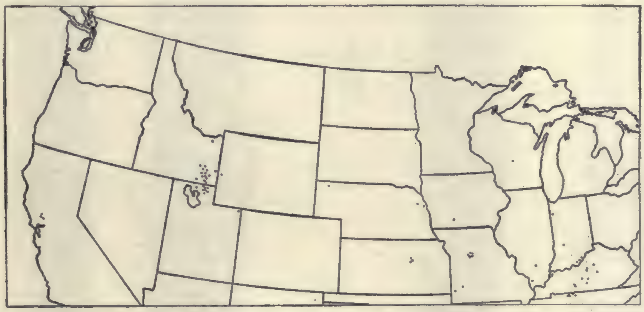


FIG. 30.—Outline map of the northwestern United States, showing where Odessa wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 54,200 acres.

Rural New Yorker No. 6 is not a high-yielding variety in the sections where it has been tested and should be displaced by more productive varieties.

SQUAREHEADS MASTER.

Squareheads Master (known also as Australian Club, Brown Squarehead, and Redchaff Red Russian) is later than Rural New Yorker No. 6 and has softer kernels. It has erect, compact, clubbed heads and white, stout, strong straw. Squareheads Master is nearly identical with the Red Russian variety discussed in section 1 except in having brown chaff.

Squareheads Master is an English wheat originated by selection from a variety known as Scholey's Squarehead. It is not known to have been distributed in this country. This wheat (or one almost identical with it) occurs as a common mixture in Red Russian grown in California, Idaho, and Washington. Occasionally it has been separated and grown alone. A small acreage of the variety is grown now in Washington.

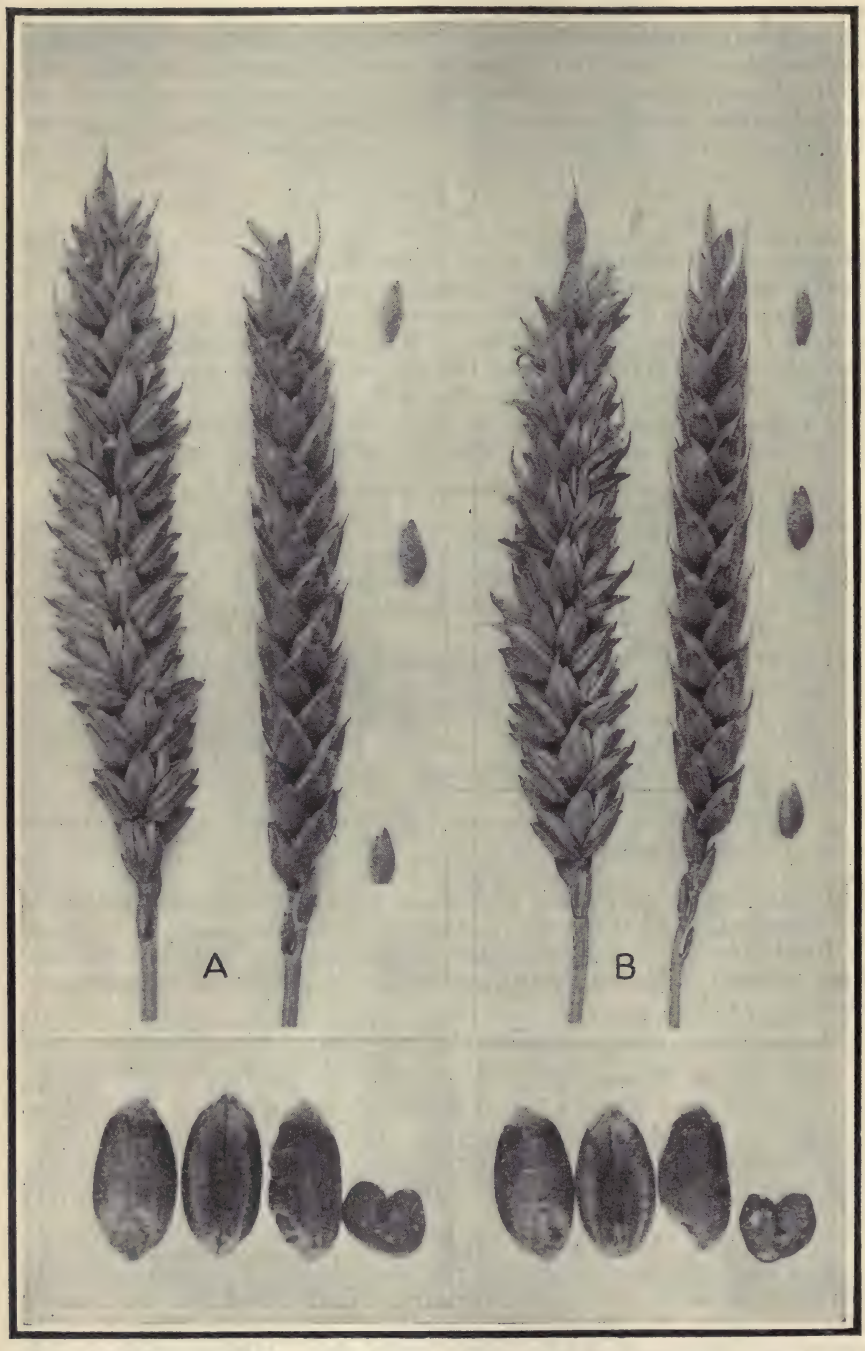


FIG. 31.—Heads, chaff, and kernels of Mealy (*A*) and Jones Fife (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

This wheat has the same adaptation as Red Russian and should be grown only in the humid sections of western Washington. As the kernels of the two varieties are identical, they probably are of equally poor milling and baking quality.

Section 3.—HEADS BEARDLESS; CHAFF PUBESCENT (VELVETY), WHITE OR YELLOW.

This section includes three commercial varieties differing from those previously described in having velvety or hairy chaff.

JONES FIFE (JONES WINTER FIFE).

Jones Fife (known also as Burbank's Super, Canadian Hybrid, Crail Fife, Fife, Fishhead, Silver King, Super, Velvet Chaff, and Winter Fife) is distinct in having long, wide, nodding, velvety heads (Fig. 31, B). The heads are oblong rather than tapering. The plants are of medium height and maturity and have white straw.

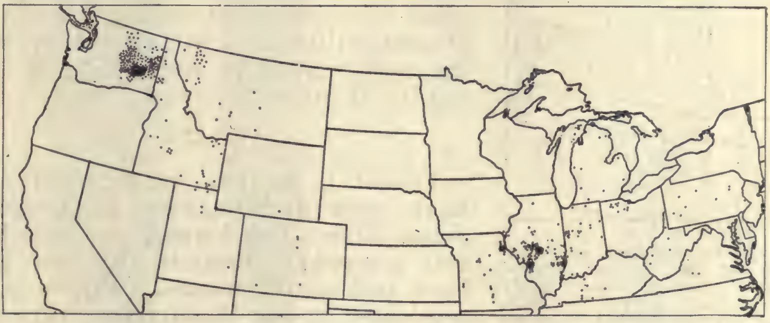


FIG. 32.—Outline map of the northern United States, showing where Jones Fife wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 476,100 acres.

The kernels are midsized, usually of semihard texture and of angular appearance.

Jones Fife was originated by A. N. Jones, of Newark, N. Y., from crosses made about 1889 between Fultz, Mediterranean, and a wheat known as Russian Velvet. Since that time this wheat has become rather widely grown. In 1917 it was distributed by Luther Burbank, of Santa Rosa, Calif., under the name Super, or Burbank's Super, with the claim that it was a new high-yielding wheat. Jones Fife is grown now both in the eastern and western parts of the United States under humid, irrigated, and semiarid conditions. It is most important in Washington, Illinois, Missouri, Indiana, and Idaho. About 476,000 acres of Jones Fife wheat were grown in the United States in 1919, distributed as shown on the accompanying map (Fig. 32).

Although widely adapted and a fairly productive variety Jones Fife is outyielde by one or more varieties in all sections where it is grown. In Washington and Idaho it is outyielded by hard red winter wheat and varieties of club wheat. In Illinois, Indiana, and Missouri such varieties as Fulcaster, Poole, Fultz, and Mediterranean have given higher yields than Jones Fife.

In milling and baking quality Jones Fife is among the poorer soft red winter wheats, the flour from it producing a poor loaf of bread.

MEALY.

Mealy (White Velvet Chaff, Velvet Chaff, and Velvet Head) differs from Jones Fife in having more erect and tapering heads and shorter and harder kernels (Fig. 31, A). The kernels have a long brush (tuft of hairs at the tip). Mealy originated from three heads of wheat found growing in a field of Fultz by M. A. Mealy in 1880. In 1885 and for several years thereafter Mealy was distributed by the United States Department of Agriculture.

Mealy is now grown in about 11 Eastern and Southern States. About 65,000 acres of Mealy were grown in 1919, distributed as shown on the accompanying map (Fig. 33). It is most important in Ohio, Pennsylvania, and Tennessee.

In general, Mealy has yielded less than several wheats where it is grown. Apparently it gives its best yields in eastern Ohio and western Pennsylvania and a section of northern Tennessee. In these sections, however, it yields less than several of the best varieties, by which it could be displaced profitably. Mealy is of poor milling and baking quality, being very similar to Jones Fife in the quality of bread produced.

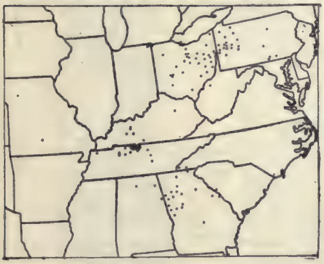


FIG. 33.—Outline map of a portion of the eastern United States, showing where Mealy wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 65,500 acres.

TRIPLET.

Triplet is earlier, shorter, and has more erect and tapering heads than Jones Fife. The kernels are rounded and somewhat resemble those of the hard red winter wheats. Triplet was originated at the Washington Agricultural Experiment Station by crosses involving Jones Fife, Little Club, and Turkey. It was distributed first in 1918 and is grown now to some extent in Washington and Oregon.

Triplet has given good yields in the Palouse section of eastern Washington and in the Columbia Basin of Oregon. Although perhaps not the best variety of wheat for those sections, it probably will increase during the next few years because of its comparatively large yields. It is preferable to Jones Fife in eastern Washington.

Triplet is of rather poor milling and baking quality as compared with the better soft red winter wheats, but is much superior to Jones Fife and Red Russian, the soft red winter wheats with which it must compete.

Section 4.—HEADS BEARDLESS; CHAFF PUBESCENT (VELVETY), BROWN OR RED.

This section consists of one commercial variety, Grandprize, which differs from the wheats in section 3 in having brown instead of white chaff.

GRANDPRIZE (ST. LOUIS GRAND PRIZE).

Grandprize (known also as Bull Moose, Golden Chaff, New Genesee, and Velvet Head) has short, compact, inclined, clubbed heads. The heads are not of uniform shape, however (Fig. 34, A). The

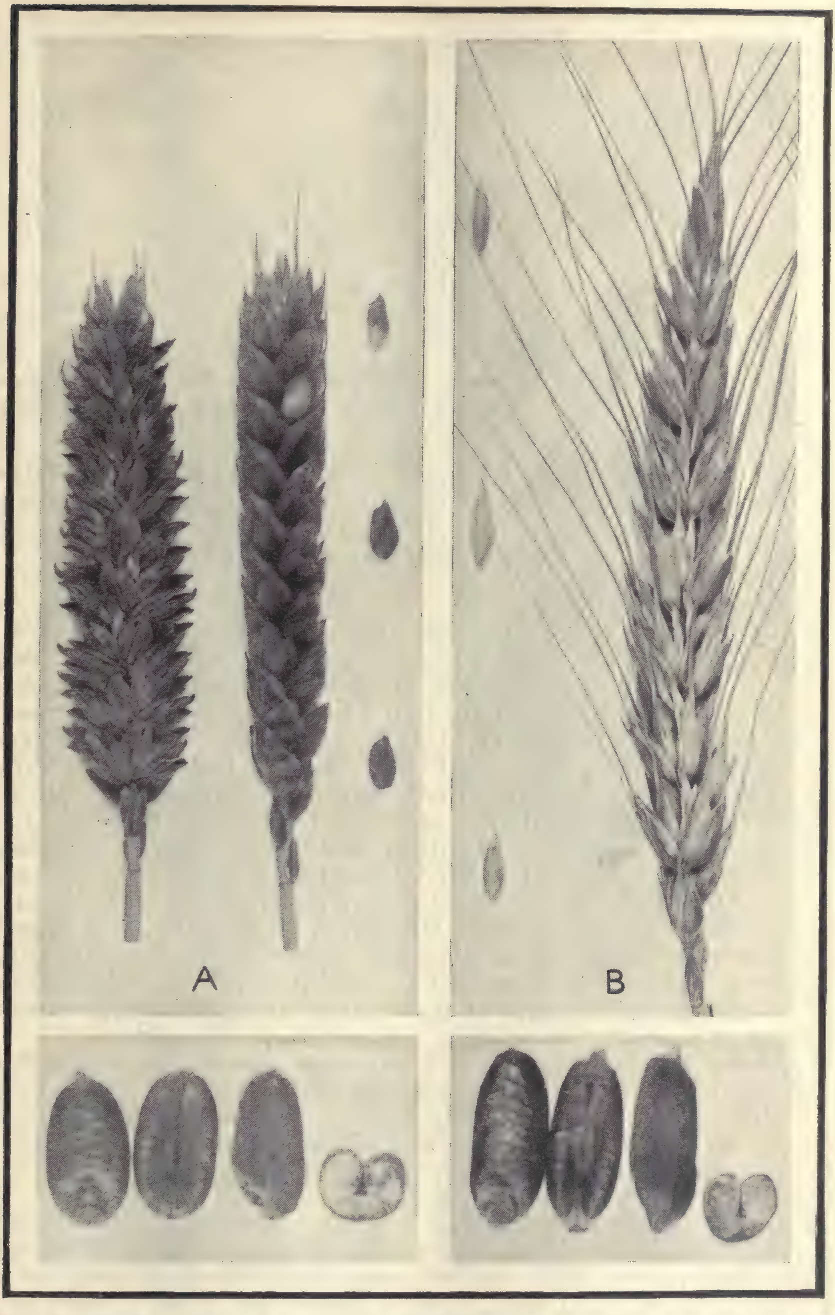


FIG. 34.—Heads, chaff, and kernels of Grandprize (*A*) and Silversheaf (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

plants are short, rather late, and have white straw. The kernels are of medium length but are wide and have a deep crease and a large brush. They are soft to semihard in texture.

Grandprize was originated by A. N. Jones, of Le Roy, N. Y., between the years 1900 and 1908. It was distributed in 1910 by Peter Henderson & Co., seedsmen, of New York City. Grandprize is grown now in at least eight Eastern States and is most important in Pennsylvania. Only about 34,000 acres of this variety were grown in the United States in 1919, distributed as shown in Figure 35.

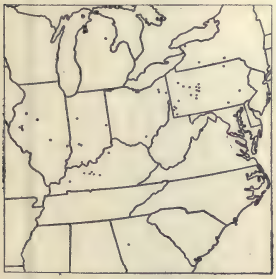


FIG. 35.—Outline map of a portion of the eastern United States, showing where Grandprize wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 34,100 acres.

Grandprize is a rather late variety, not as productive as several of the more widely grown wheats, and should be displaced.

Section 5.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), WHITE OR YELLOW.

This section consists of 11 commercially grown varieties of wheat having bearded heads. The varieties differ principally in straw color and in the size of the kernels.

FULCASTER.

Fulcaster is known also under the following names: Acme, Acme Bred, Bearded Bluestem, Bearded Purplestraw, Blankenship, Blue Ridge, Bluestem, Canadian, Champion, Corn, Cumberland Valley, Dietz, Dietz Longberry, Dietz Longberry Red, Ebersole, Eversole, Egyptian Amber, Farmers Friend, Georgia Red, Golden Chaff, Golden King, Greening, Improved Acme, Ironclad, Kansas Mortgage Lifter, Kentucky Giant, Lancaster, Lancaster-Fulcaster, Lincoln, Martha Washington, Michigan Red Line, Moore's Prolific, Number 10, Price's Wonder, Red Wonder, Stoner (Eden, Famine, Forty-to-One, Half Bushel, Kentucky Wonder, Marvelous, Millennium, Millennial Dawn, Miracle, Multiplier, Multiplying, New Light, New Marvel or Goose, Peck, Russellite, Russell's Wonder, Stooling, Two Peck, Three Peck, Wonderful), Turkish Amber, Tuscan Island, and Winter King. Several of these names are used also for other varieties of wheat.

Fulcaster is distinguished by the orange-colored stripes on the chaff. It has rather large, bearded, tapering, inclined heads, and white (orange-striped) chaff (Fig. 36, A). The beaks (points on the outer chaff) are less than one-third of an inch in length. The plants are of medium height and maturity and the straw is purple. The kernels of Fulcaster are midlong, rather thick, and usually soft.

Fulcaster is reported to have originated in 1886 from a cross between Fultz and Lancaster (Mediterranean) made by S. M. Schindel, of Hagerstown, Md. In 1884, two years previous to the date mentioned above, the Dietz or Dietz Longberry, which is identical with Fulcaster, was obtained from George A. Dietz, of Chambersburg, Pa., by the Ohio Agricultural Experiment Station. The true origin of Fulcaster, therefore, is rather doubtful, but it probably is an older variety than these histories indicate. Fulcaster has been

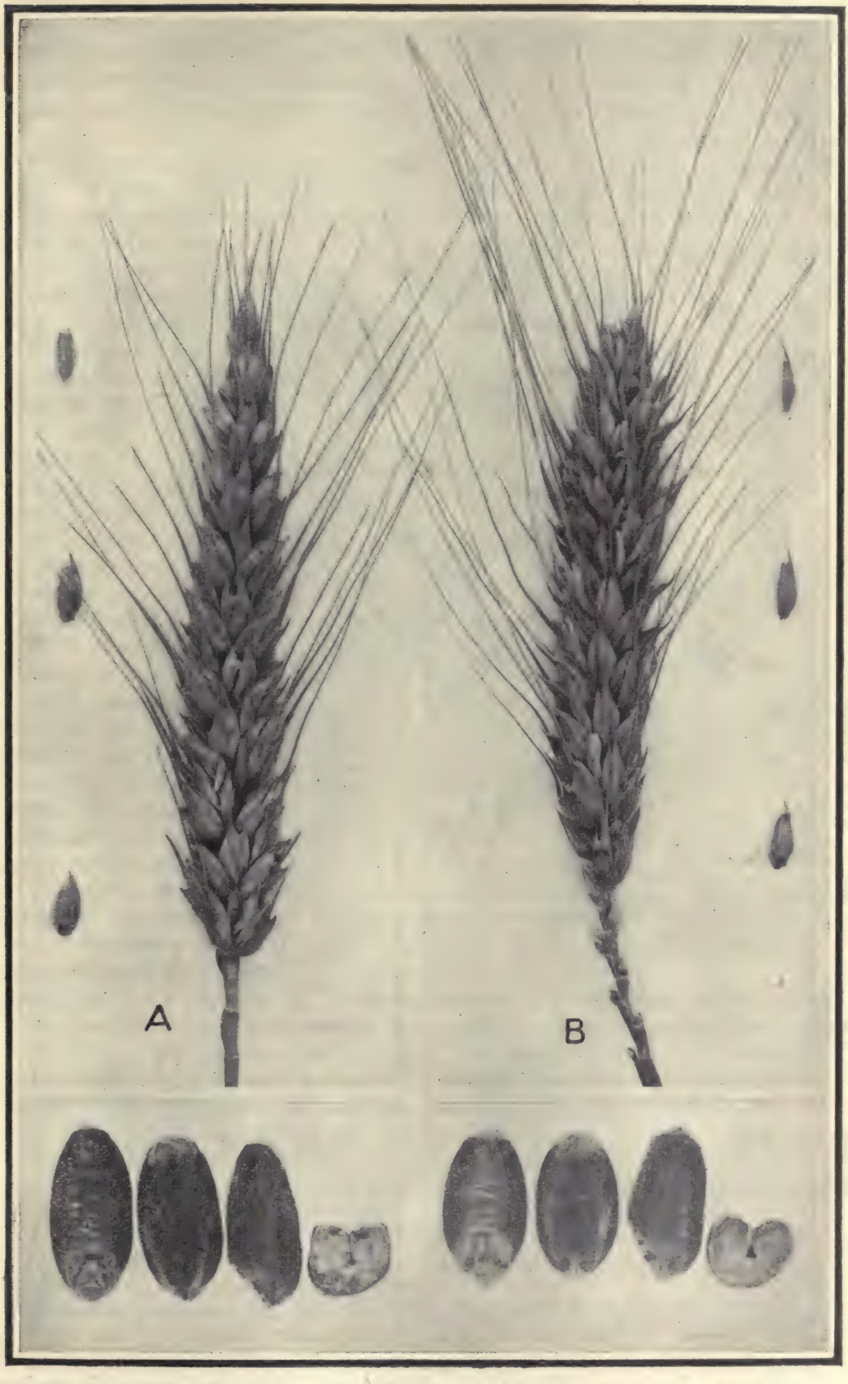


FIG. 36.—Heads, chaff, and kernels of Fulcaster (*A*) and Golden Cross (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

exploited on several occasions by firms who made extravagant claims concerning the productivity or tillering of the variety. Names such as Miracle, One-Peck-to-the-Acre, and Millennium were applied thus to a strain of Fulcaster. In spite of the claims of its heavy tillering, Fulcaster and strains of this type should be sown at the same rate as other varieties.

Fulcaster, under the numerous names listed above, is now grown in at least 26 States in the eastern half of the United States. The belt of heaviest production extends in a southwesterly direction from New Jersey to western Oklahoma. Fulcaster is grown most widely in Virginia, Pennsylvania, Oklahoma, Tennessee, Missouri, North Carolina, and Maryland. In 1919 about 2,576,000 acres of Fulcaster were grown in the United States, distributed as shown on the accompanying map (Fig. 37). It is second in importance among the soft red winter wheats and ranks fourth among all wheat varieties.

Fulcaster is perhaps the highest yielding variety of wheat in most parts of eastern Kansas, Missouri, southern Illinois, Tennessee, western Virginia, and Maryland. It is one of the best varieties in Oklahoma, Arkansas, North Carolina, Georgia, South Carolina, Pennsylvania, Delaware, and New Jersey. In general, it is well adapted to the Eastern and Southern States. It does not have as stiff straw as some other varieties and frequently is objected to on account of its being bearded. Fulcaster could displace with profit many of the varieties now grown in the sections where it is known to be very productive.

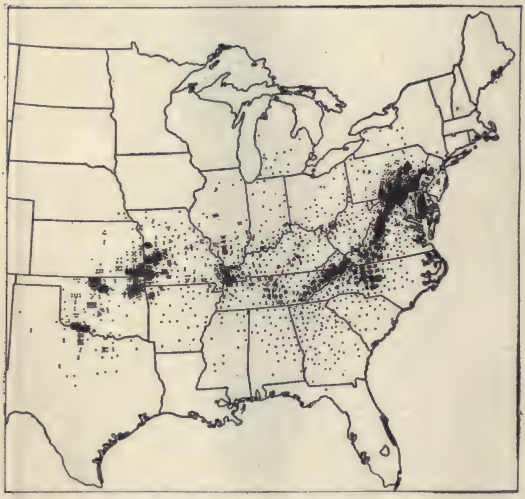


FIG. 37.—Outline map of the eastern United States, showing where Fulcaster wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 2,576,500 acres.

In milling and baking quality Fulcaster ranks with the better varieties of soft red winter wheat and is practically equal to Fultz and Poole. Under favorable but dry conditions in Kansas, Texas, and Oklahoma the kernels of Fulcaster become rather hard, and it then is nearly equal in quality to hard red winter varieties.

MAMMOTH RED.

Mammoth Red differs from Fulcaster in having a slightly larger and harder kernel and generally slightly longer beaks. The origin of this wheat is not known, but it was distributed by the David Hardie Seed Co., of Dallas, Tex., during the early nineties. It now is grown in Indiana, Maryland, Michigan, Missouri, and Virginia.

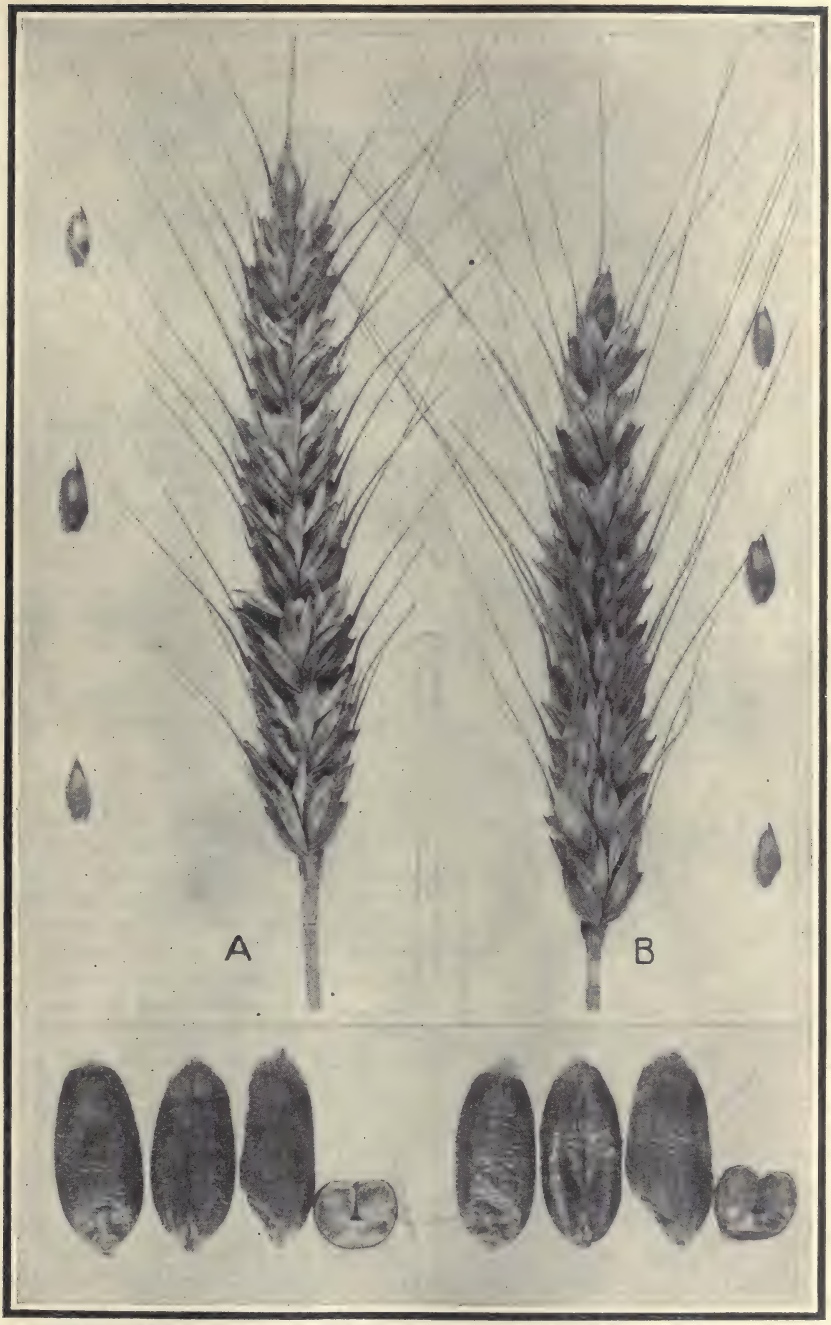


FIG. 38.—Heads, chaff, and kernels of Rudy (*A*) and Nigger (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

Mammoth Red has yielded as well as or better than Fulcaster in Maryland, and is fully equal to Fulcaster in milling and baking quality.

NIGGER.

Nigger (Winter Green, Winter John, and Winter King) differs from Fulcaster chiefly in having longer kernels and being slightly taller. The beaks (short beards on the outer chaff) of Nigger are shorter than those on Fulcaster, being only about one-sixteenth of an inch in length (Fig. 38, B).

Nigger is reported to have originated from a plant found by a colored man named Sampson on his farm in Darke County, Ohio. It is of most importance in Ohio, Indiana, and Michigan. About 280,000 acres of this variety, distributed as shown on the accompanying map (Fig. 39), were grown in 11 States in 1919.

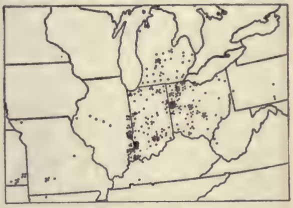


FIG. 39.—Outline map of the central United States, showing where Nigger wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 280,600 acres.

Nigger has given fair yields in Ohio, but in recent years has been outyielded by new wheats such as Gladden, Portage, and Trumbull. In Indiana, Nigger has yielded less than several other varieties. It is a promising variety in West Virginia, although not grown extensively in the State at present.

Nigger is among the better soft red winter wheat varieties in milling and baking quality, being about equal to Fultz and Poole.

GIPSY.

Gipsy (known also as Defiance, Egyptian, Farmers Friend, Golden Straw, Grains o' Gold, Gipsy Queen, Lebanon, Niagara, and Reliable) differs from Fulcaster in having white or yellow instead of purple straw, and in not having the distinct orange-colored stripes on the chaff (Fig. 41, A). The origin of Gipsy is not known. It was grown in Missouri as early as 1877. A tradition has been reported that the wheat was obtained from a gipsy. About 122,000 acres of Gipsy were grown in 1919, distributed in about 13 States, as shown on the accompanying map (Fig. 40), but it is important only in Ohio.

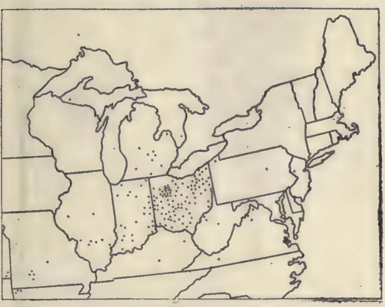


FIG. 40.—Outline map of the northeastern United States, showing where Gipsy wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 122,500 acres.

Gipsy has given good yields in West Virginia and Delaware. In Ohio it is outyielded by several other varieties of wheat. Except in certain localities it probably should be displaced by other varieties, and even in these localities Gladden, a selection of Gipsy, should probably be substituted for it. Gipsy is of only fair milling and

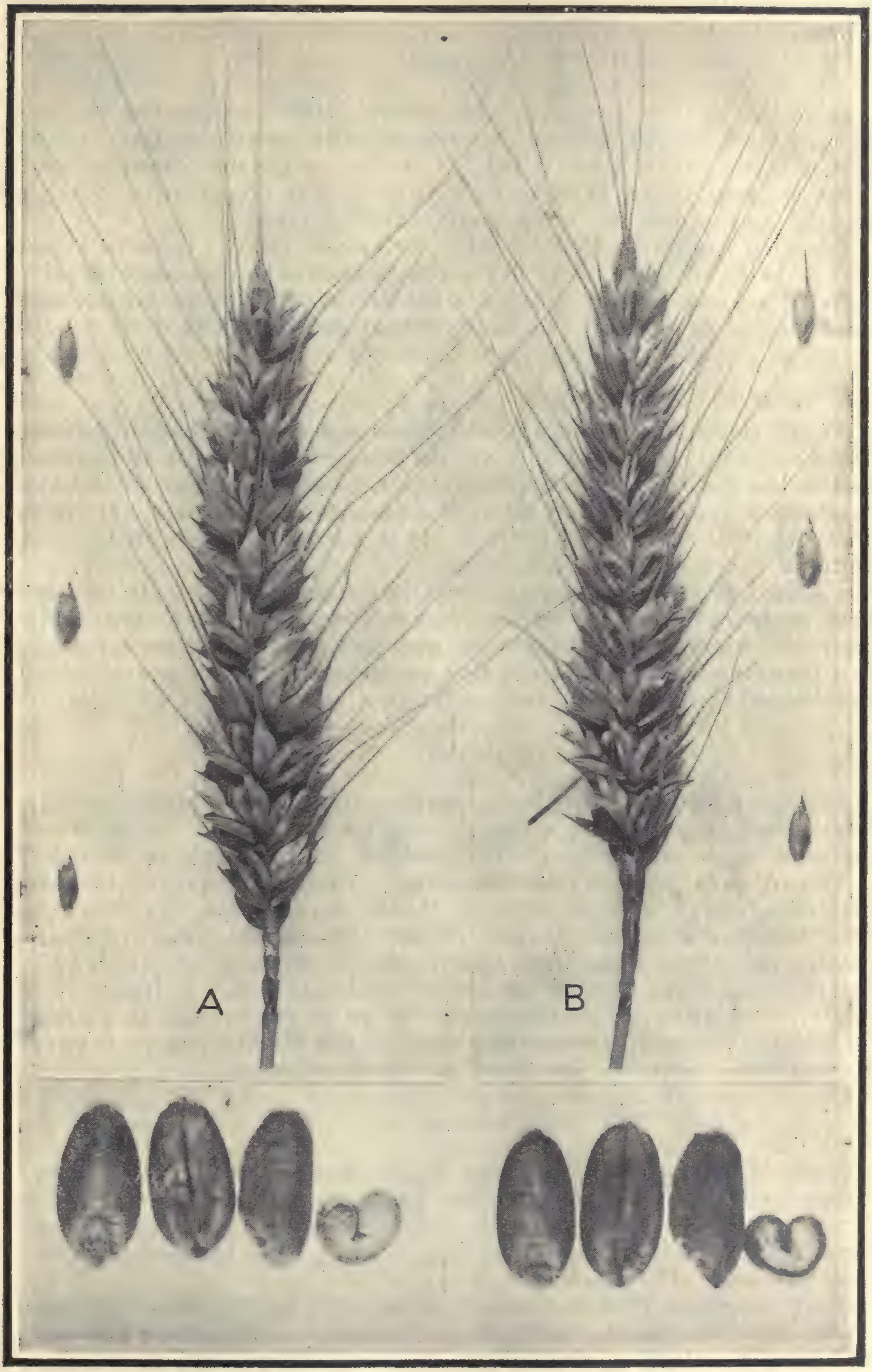


FIG. 41.—Heads, chaff, and kernels of Gipsy (*A*) and Valley (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

baking quality and is exceeded by many of the soft red winter wheats.

GLADDEN.

Gladden is very similar to Gipsy but differs in having shorter beaks, which usually are less than one-eighth of an inch long. It also has stronger straw than Gipsy. Gladden originated from a head selected from Gipsy at the Ohio Agricultural Experiment Station in 1905 and is now grown in many parts of Ohio.

Gladden has outyielded all other wheats in many places in Ohio. The growing of this variety in that State should be increased largely. In milling and baking quality Gladden is superior to Gipsy and nearly equal to any soft red winter wheat grown in Ohio.

VALLEY.

Valley (German Amber, Indiana Swamp, Niagara, Russian Amber, and Rustproof) differs from Gipsy in being slightly taller and earlier and in having longer heads (Fig. 41, B). Valley is reported to have originated in the Scioto Valley of Ohio, but the variety of wheat from which it came is not known. It is grown sparingly in Illinois, Indiana, Kansas, Ohio, and Texas.

Valley has given good yields in Ohio and Delaware. It has not been one of the highest yielding varieties in any section and could be displaced in Ohio by Gladden and in the other States where it is grown by other more productive varieties. Valley is nearly equal to Gladden in milling and baking quality but is inferior to Fultz.

SIBLEY.

Sibley, or Sibley's New Golden, differs from Gipsy chiefly in being later in maturity. Other wheats having brown chaff or purple straw are sometimes called Sibley's New Golden, but the one here discussed is known most generally by this name. Sibley is reported to have originated from a cross between Mediterranean and Clawson. It was distributed by the United States Department of Agriculture during the late eighties and was formerly grown to a considerable extent in the Ohio Valley, but is not found there now. It is grown now very sparingly in Oklahoma. It gives fair yields in eastern Oklahoma, but usually lower than those of the Mediterranean variety. It probably should be displaced by Mediterranean.

RUDY.

Rudy (known also as Anti-Rust, Black Mediterranean, Early Rudy, Kentucky Giant, and Queen of New York) is distinct in having black stripes along the margins of the chaff. The heads are long, open, tapering, and rather nodding (Fig. 38, A). The kernels are quite long and soft. The straw is white or yellow.

Rudy originated from a wheat plant found by M. Rudy at Troy, Ohio, in 1871. The variety since has become widely grown and now is found in at least 15 States, but is of importance only in Indiana, Ohio, and Pennsylvania. About 400,000 acres of Rudy, distributed as shown on the accompanying map (Fig. 42), were grown in 1919.

Rudy is one of the most productive varieties in Indiana and southern Illinois, but is not especially promising in other sections. It is of good milling and baking quality, being equal to most of the soft red winter wheats.

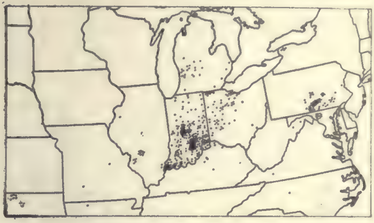


FIG. 42.—Outline map of a portion of the eastern United States, showing where Rudy wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 399,400 acres.

SILVERSHEAF (JONES SILVER SHEAF LONGBERRY RED).

Silversheaf (Australian, Clipperd's Bearded, Coffee, and Davis) differs from Rudy in having dark coffee-colored stripes on the chaff instead of black stripes on the chaff margins (Fig. 34, B). The beaks of Silversheaf also are longer than those of Rudy. The straw usually is white or yellow, but mixtures of purple-strawed plants are found also. The kernels are pale red, long, and soft, and are easily shattered from the heads.

Silversheaf was originated by A. N. Jones, of Le Roy, N. Y., in 1903 by crossing Prosperity (American Bronze) and an unnamed hybrid. The wheat was distributed first by Peter Henderson & Co., seedsmen, of New York City. It is grown in Maryland, New York, North Carolina, and West Virginia. About 35,000 acres of Silversheaf were grown in 1919, distributed as shown in Figure 43.

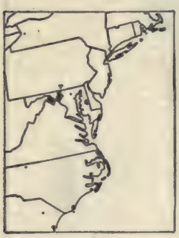


FIG. 43.—Outline map of a portion of the eastern United States, showing where Silversheaf wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 34,900 acres.

In the sections of Maryland, Pennsylvania, and West Virginia where most of the Silversheaf is grown, Fulcaster has given higher yields. The latter variety probably should displace Silversheaf.

GOLDEN CROSS.

Golden Cross differs from other varieties discussed in this section in having club-shaped heads (Fig. 36, B). The straw is purple and rather short and stout. The kernels are midlong, wide, and soft to semihard. This wheat was originated by A. N. Jones at Newark, N. Y., in 1886, apparently as a result of a cross between Mediterranean and Clawson. It was distributed first in 1888.

Golden Cross is grown on a small scale in Kentucky, Michigan, Ohio, and Oregon. It has not given high yields, however, and should be displaced by more productive varieties.

NEBRASKA NO. 28.

Nebraska No. 28 (or Nebraska Hybrid No. 28) is much earlier than any of the other wheats in this section. The plants are short and extremely early. The straw is white or yellow. The kernels

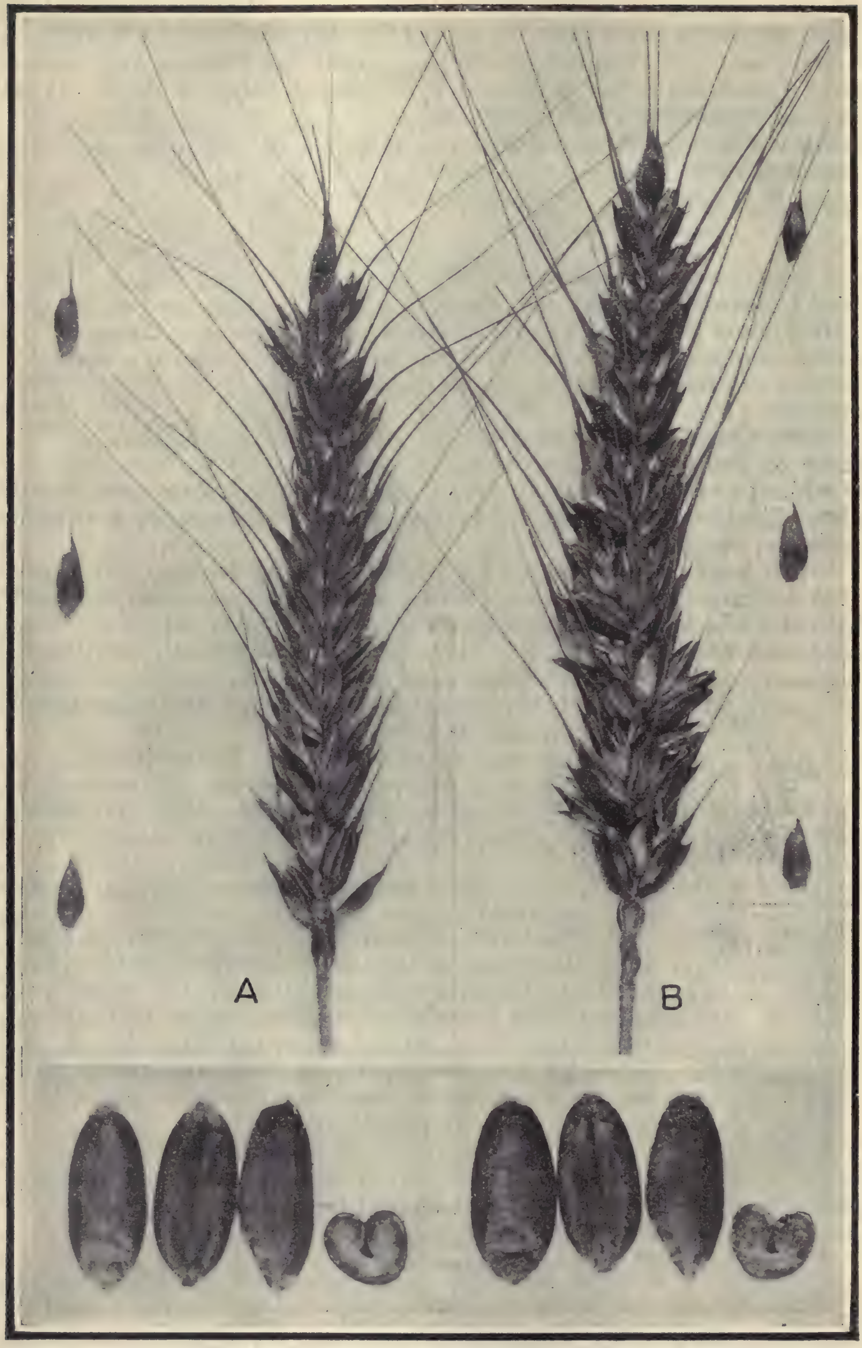


FIG. 44.—Heads, chaff, and kernels of Mediterranean (*A*) and Red Rock (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

are rather small, soft to semihard, and are easily shattered from the heads.

This wheat is the result of a cross between Big Frame and Turkey (a hard red winter wheat) made at the Nebraska Agricultural Experiment Station in 1902. Off-type plants often are found in it. It was distributed in Nebraska in 1916 and probably is grown there to some extent now. Because of its earliness it will give high yields in some seasons in various sections of the country. On the average it can not compete with the hard red winter wheats in the Great Plains area nor with the most productive varieties in other regions.

Nebraska No. 28 is of fair milling and baking quality, being poorer than many of the soft red winter wheats.

Section 6.—HEADS BEARDED; CHAFF GLABROUS (NOT VELVETY), BROWN OR RED.

The wheats in this section differ from those in the previous section in having brown or red instead of white or yellow chaff. There are five varieties which are grown commercially.

MEDITERRANEAN.

Mediterranean is known also as Acme, Bluestem, Farmers Trust, Great Western, Key's Prolific, Lancaster Red, Lehigh, Miller, Miller's Pride, Missouri Bluestem, Mortgage Lifter, Redchaff, Red Sea, Red Top, Rocky Mountain, Standby, and Swamp. This wheat has long, tapering, bearded, brown-chaffed heads and very long, soft red kernels (Fig. 44, A). The plants are tall, midseason in maturity, and have purple straw.

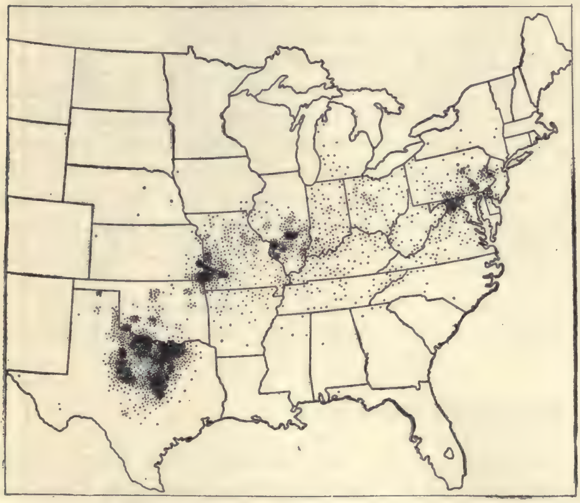


FIG. 45.—Outline map of the eastern United States, showing where Mediterranean wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area, 2,558,900 acres.

The most authentic history of the Mediterranean variety indicates that it was introduced from Genoa, Italy, in 1819, by John Gordon, of Wilmington, Del. During the next 30 or 40 years it rapidly became more popular and spread into the western wheat-growing regions. Mediterranean is grown now in about 27 Eastern and Southern States, but is of most importance in Texas, Missouri, Oklahoma, Illinois, and Pennsylvania. In 1919 about 2,560,000 acres of Mediterranean, distributed as shown on the accompanying map (Fig. 45), were grown in the United States, Texas alone having more than 1,330,000 acres. It is the third most important variety of soft red winter wheat in this country.

Mediterranean is the highest yielding variety of wheat in the humid sections of Texas and Oklahoma. It has given very good yields in southeastern Kansas under the name Red Sea, and also in portions of Missouri. Mediterranean is a fairly productive variety in Delaware and Pennsylvania. In the remaining Eastern and Southern States other varieties have outyielded it. Mediterranean wheat is of good milling and baking quality but not quite equal to Fultz and Poole.

RED ROCK.

Red Rock is very similar to Mediterranean but has larger and more open heads and thicker and harder kernels (Fig. 44, B). Red Rock was originated from a head found as a mixture in Plymouth Rock, a white common wheat, at the Michigan Agricultural Experiment Station about 1908. It was distributed first in Michigan in 1914 and soon became widely grown in that State. It is also grown in Connecticut, Illinois, Indiana, and Ohio. Red Rock wheat is found in its greatest abundance in the southern half of Michigan. The distribution of this variety is shown on the map in Figure 46.

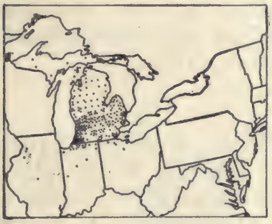


FIG. 46.—Outline map of a portion of the northern United States, showing where Red Rock wheat was grown in 1919. Each dot represents 1,000 acres or fraction thereof per county. Estimated area. 216,000 acres.

Red Rock has outyielded all other varieties of wheat in the southern half of Michigan and has given good yields in the extreme northern counties in Indiana and Ohio. It is not sufficiently winter hardy for growing in northern Michigan or in the central hard red winter-wheat region. In the States south of Michigan other varieties usually have outyielded Red Rock.

In milling and baking quality Red Rock is perhaps the best of the soft red winter wheats. Flour from this wheat produces an excellent loaf of bread.

DIEHL-MEDITERRANEAN.

Diehl-Mediterranean is known also as Auburn, Big Four, Big Ten, Blue Ridge, Eclipse, Hybrid Mediterranean, Michigan Bronze, Michigan Brown, Miller's Choice, Rattle Jack, Russian Amber, Shepherd's Perfection, Shepherd's Prolific, and Spade. This variety differs from Mediterranean principally in having a smaller kernel and white or yellow instead of purple straw (Fig. 47, A). Diehl-Mediterranean is reported to have originated from a cross between Mediterranean and Diehl (a beardless white wheat). It was distributed first in 1884 by Peter Henderson & Co., seedsmen, of New York City. During several succeding years it was distributed also by the United States Department of Agriculture.

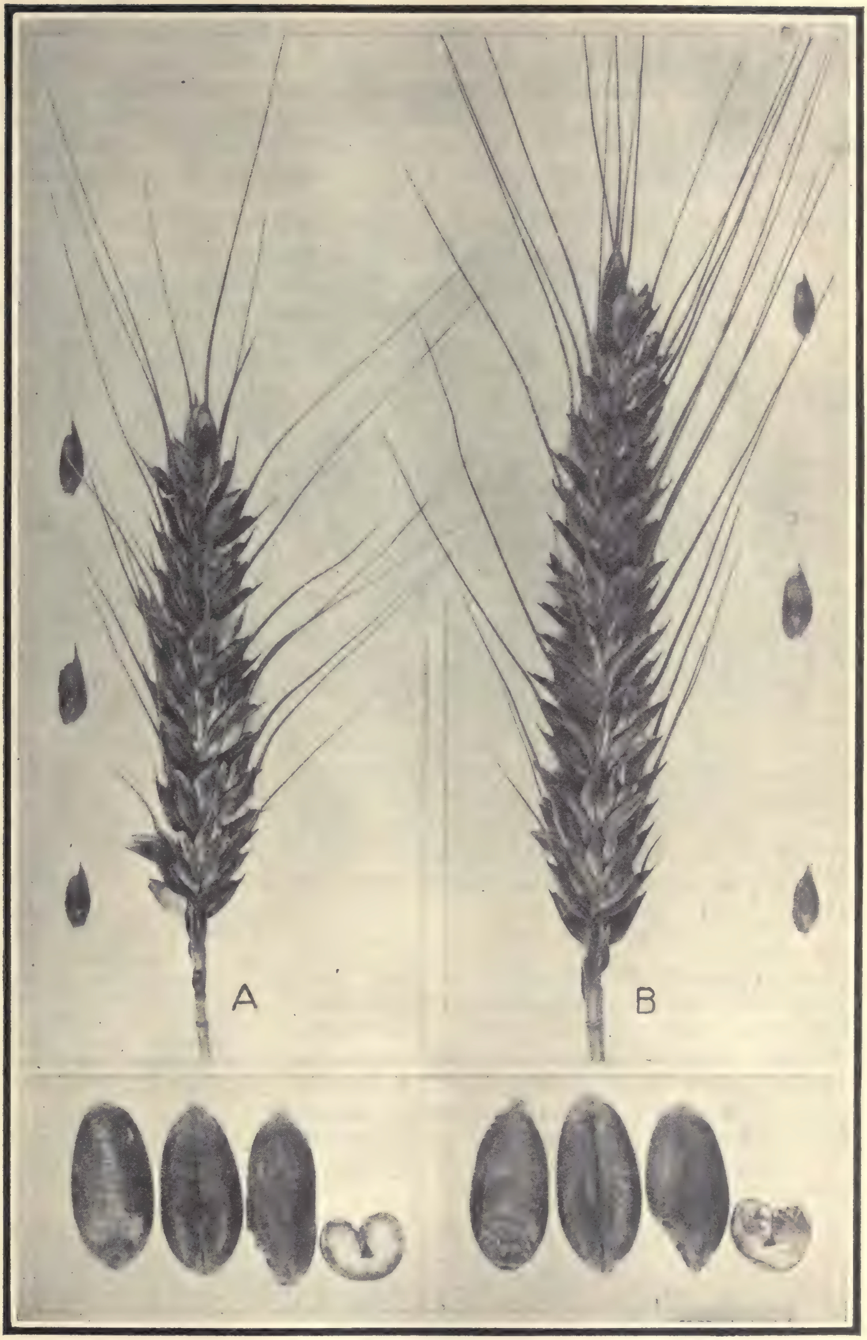


FIG. 47.—Heads, chaff, and kernels of Diehl-Mediterranean (*A*) and Goens (*B*) wheats. Heads and chaff natural size, kernels in three positions and in cross section magnified 3 diameters.

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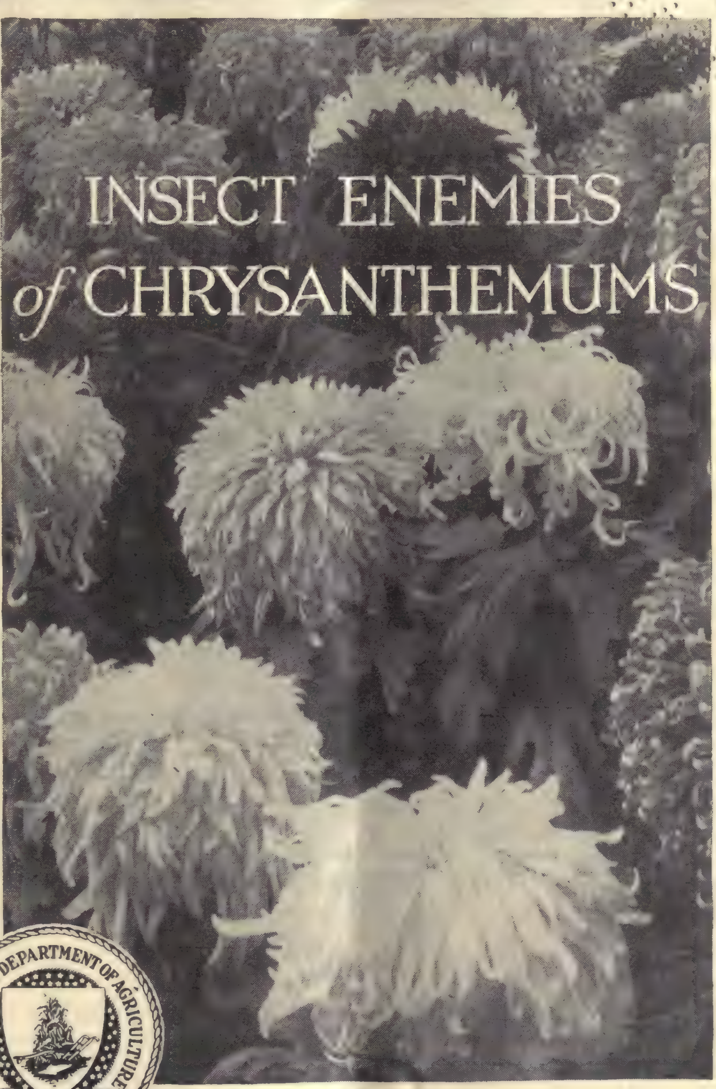
This bulletin is a contribution from the—

Bureau of Plant Industry	William A. Taylor, *Chief.*
Office of Cereal Investigations	Carleton R. Ball, *Cerealist in Charge.*

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1306



INSECT ENEMIES of CHRYSANTHEMUMS

1862 1889

Corrections for Farmers' Bulletin 1306

On page 2, last line of third paragraph, the reference to "pages 23 to 34" should be changed to "pages 25 to 36." Similar changes should be made on several other pages, the passages referred to being found 2 pages beyond the places indicated.

On page 4, the ninth line from the bottom should read as follows:

"pupal skin. The skin then splits down
the middle of the head and"

Methods of control are discussed in connection with each pest, and general formulas for insecticides and fumigants are given on pages 23 to 34.

Title page illustrates a portion of the Department's 1921 chrysanthemum show
Photograph by Ernest L. Crandall, Bureau of Plant Industry.

Washington, D. C. February 23, 1923

INSECT ENEMIES OF CHRYSANTHEMUMS.

CHARLES A. WEIGEL,
Entomologist, Greenhouse Insect Investigations, Bureau of Entomology.

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DESTRUCTIVE CHRYSANTHEMUM INSECTS.

CHRYSANTHEMUMS, which rank among the more valuable productions of the florist, are grown under ideal atmospheric conditions which not only favor the plants but enable insect pests to thrive and to multiply rapidly the year round. The losses occasioned to the chrysanthemum grower by insects alone amount to large sums annually, which, however, could be greatly reduced by proper care, based on knowledge of the insects and their habits.

Of the many insects known to attack and feed on chrysanthemums, the chrysanthemum midge, the greenhouse leaf-tyer, the black and green aphids or plant-lice, the common greenhouse red spider, thrips, and white flies are probably the most destructive. The chrysanthemum midge, which was introduced in 1915, has become widely distributed over the entire country and is now probably the most serious insect enemy of this crop. The greenhouse leaf-tyer has been reported on several occasions as practically ruining the entire stock of plants in which it occurred. Aphids frequently inflict a greater amount of injury than is credited to them. Likewise the injury caused by the common red spider, thrips, and white flies is often underestimated. Next in importance may be mentioned cutworms, scale insects, the chrysanthemum leaf-miner, and several leaf-eating insects, such as the caterpillars and leaf-beetles.

CHRYSANTHEMUM MIDGE.

The chryanthemum midge,[1] an insect of European origin, was first reported as occurring in this country in 1915. Since then it has become firmly established and is now one of the most important chrysanthemum pests, causing thousands of dollars' worth of damage annually.

---

[1] *Diarthronomyia hypogaea* Löw.

INJURY.

The midge renders the foliage practically valueless for commercial purposes even when only lightly infested. In severe infestations the plants fail to bloom because of the dwarfed, knotted, and gnarled condition, which prevents the formation of the new central stem (Fig. 1). When plants are attacked at the time the crown buds are setting, the flowers become distorted and are not borne upright as normal flowers should be.

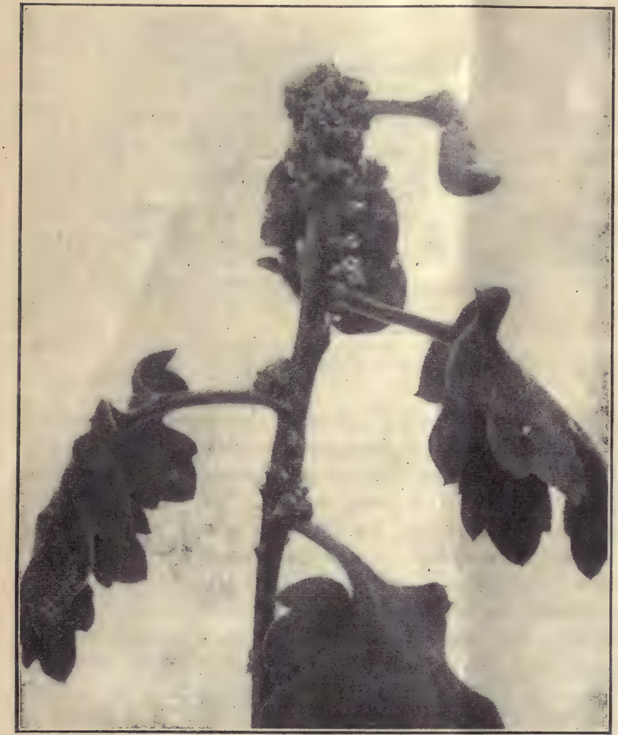

FIG. 1.—Injury to terminal growth of chrysanthemum by the chrysanthemum midge.

LIFE HISTORY.

The presence of this insect on chrysanthemums is usually shown by the existence of well-developed galls. These galls, when fully developed, are about one-twelfth of an inch long and occur on the leaf, stem, or flower head of the plant, projecting obliquely from the surface. After the larvæ hatch from the orange-colored eggs, which are deposited by the female fly on the surface of tender tips and new growth, they bore their way into the tissues. As a result of this irritation cone-shaped galls are formed. When the leaf is affected (Fig. 2) the galls occur usually on the upper surface, although a slight swelling may also be observed on the opposite or under side of the leaf. Growth and development of both larva and pupa take place within the gall. When the pupa is fully developed it pushes itself out of the gall, still inclosed in the pupal skin protruding from the opening of the empty gall. In the back to allow the fly to emerge. On emerging, the fly leaves its pupal skin protruding from the opening of the empty gall. In the adult stage (Fig. 3) the midge is a fragile two-winged fly one-fourteenth of an inch long; the abdomen of the male is yellowish orange, while that of the female is reddish orange.

The flies emerge after midnight, and the eggs, which are laid early in the morning, hatch within from 3 to 16 days, depending upon the temperature. The larva or maggot, upon hatching from the egg, moves about on the surface for a period of from 1 to 3 days prior to boring into the tissue. Within 7 days, on the average, the young galls may be readily detected. It takes from 21 to 46 days, with an average of 28 days, from the time the larva first enters the tissue until the emergence of the adult. The whole life cycle from egg to adult requires about 35 days, and under greenhouse conditions there may be six generations a year.

FOOD PLANTS.

The depredations of the chrysanthemum midge in North America are confined to chrysanthemums. Practically all of the commercial sorts, both the single and pompon varieties, are attacked. While essentially a greenhouse pest this midge also lives on outdoor chrysanthemums.

CONTROL.

If the plants show only a light infestation, hand pick the gall-infested leaves daily. In heavy infestations pull up and burn the most severely infested plants, then fumigate nightly with nicotine papers or hydrocyanic-acid gas for a period of 30 to 40 days in order to kill all of the adults that emerge during such a period and thus prevent further egg laying for future generations. Fumigation should not begin until after 12.30 a. m., because the adults do not emerge before that time. Hydrocyanic-acid gas is not recommended unless in the hands of a competent fumigator.

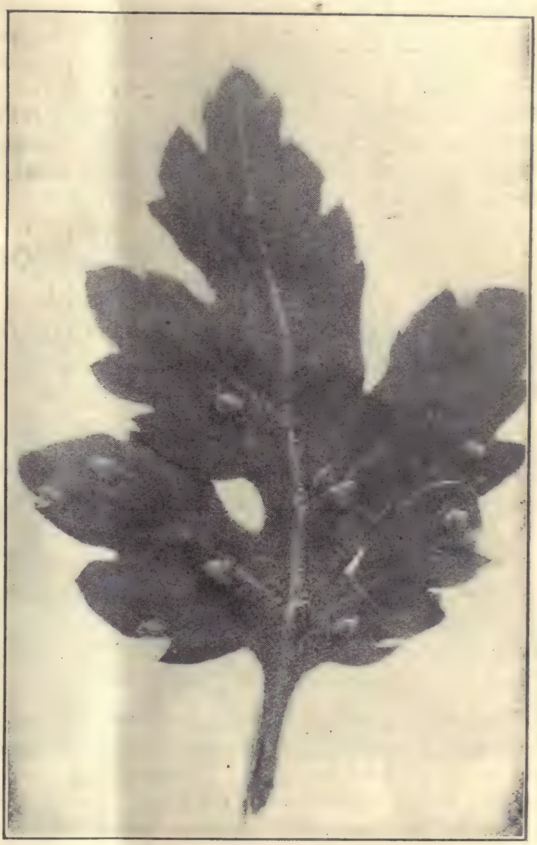

FIG. 2.—Galls of midge on chrysanthemum leaf.

If fumigation is not practicable, persistent spraying is recommended for a period of 4 to 6 weeks, the 40 per cent nicotine sulphate solution being used as outlined on page 26, which should be applied every second or third day, preferably late in the afternoon. This operates against the eggs and also against the adults at the time of their emergence.

PREVENTION.

Growers should carefully examine all chrysanthemums received, as well as all material intended for shipment or distribution, to see that they are free from this pest.

A satisfactory method of obtaining cuttings free from the midge when the previous season's stock has been infested is to plant the stock in benches or coldframes directly after the season's crop has been removed. Follow this by thorough treatment with a mixture consisting of equal parts of dry air-slaked lime and tobacco dust. It is advisable to keep all new growth covered with this mixture until further operations in the spring. Additional information on this pest may be had by consulting Department Bulletin 833, United States Department of Agriculture.

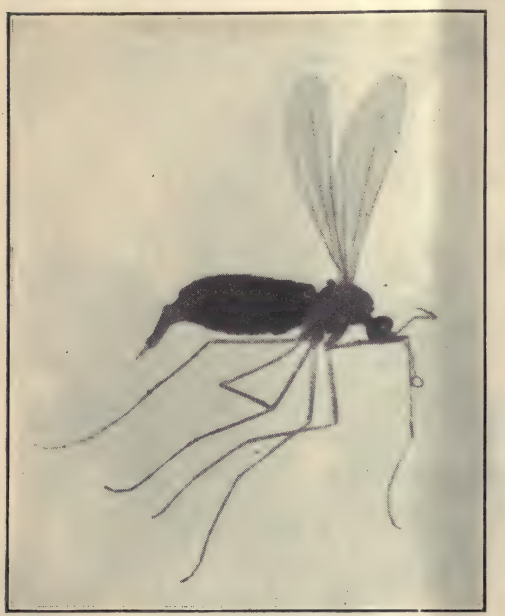

FIG. 3.—Chrysanthemum midge: Adult female.

GREENHOUSE LEAF-TYER.[2]

The greenhouse or celery leaf-tyer during recent years has been responsible for much injury to chrysanthemum, cineraria, and snapdragon and in some instances has destroyed the plants attacked (Fig. 4).

INJURY.

The injury is caused by the larvæ, or caterpillars (Fig. 5), feeding on the under side of the foliage, where they eat away the soft tissue, usually leaving the top surface intact. At times, however, they devour the entire tissue in the areas where they are feeding. Normally they feed within lightly woven silken webs, between the surfaces of the edge of a single leaf folded over, or between two or more contiguous leaves tied together. The injury resulting from these habits is twofold: The plant is weakened, and the disfigurement of the leaves greatly diminishes the market value.

LIFE HISTORY.

The eggs (Fig. 6, *c*) are about three-fifths of a millimeter wide, flattened, with raised centers, rounded in outline, and pearly white. In bright sunlight they appear iridescent. They are laid mostly on the under side of the leaves, either singly or in masses, and in the latter case they overlap. They hatch in from 5 to 12 days or longer.

The larvæ or caterpillars (Figs. 5 and 6, *d*, *e*, *f*), on emerging from the egg, are of a creamy white translucent color, the body being covered with long whitish hairs. Soon after feeding they take on a light greenish appearance. When resting on the under side of the leaf the head and fore part of the body are curled to the side. If disturbed they drop and suspend themselves on silken threads. They shed their skins four times before reaching the full-grown stage, which is then three-fourths of an inch long. When full grown they are dark green on the back and marked with longitudinal stripes. The sides and under surface are of a paler color. Because of the overlapping of generations, larvæ or caterpillars in all stages of development may be found on plants in greenhouses at almost any time.

---

[2] *Phlyctaenia rubigalis* Guen.

When ready to pupate the caterpillar folds over a portion of the leaf upon which it is feeding and fastens it with strands of loosely woven silk. In other cases the larva may form a slight cocoon and transform to a pupa within a shelter constructed in the same manner by drawing down a contiguous leaf as a covering, and fastening the two leaves together. At first the pupa (Fig. 6, *g*, *h*) is of a shining light brown color, later changing to darker chocolate color, and sparsely haired. From this stage, which lasts from 10 to 12 days, or longer, depending on the temperature, the adult or parent moth finally emerges.

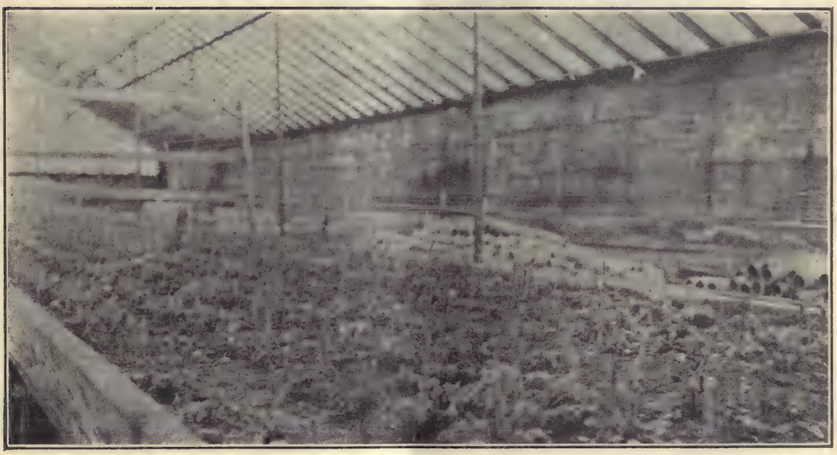

FIG. 4.—Entire house of chrysanthemums destroyed by larvæ of the leaf-tyer.

The moth (Fig. 6, *a*) has a wing expanse of three-fourths of an inch, and is of a pale brownish or rusty brown color marked crosswise with darker lines. When at rest it assumes a characteristic triangular shape (Fig. 6, *b*), measuring three-eighths of an inch at the widest part. The moths are very quiet during the day and are found resting on the under sides of leaves, under the benches, or in other sheltered places in the greenhouse. After dusk they become active and fly about or fly from plants upon the least disturbance. Egg laying may begin on the day they emerge, and the adults live from 5 to 15 days, or an average of 10 days.

At Washington, D. C., it takes from 36 to 43 days for development from egg to adult and there may be eight or more generations a year under greenhouse conditions.

CONTROL.

Inasmuch as the cuttings are taken early in the spring for the ensuing season's crop, and since the larvæ are more easily detected when the plants are small, it is evident that a serious infestation can be easily abated by keeping a vigilant watch for the caterpillars at this time. Hand picking is then very effective and practical, provided not too many plants are concerned.

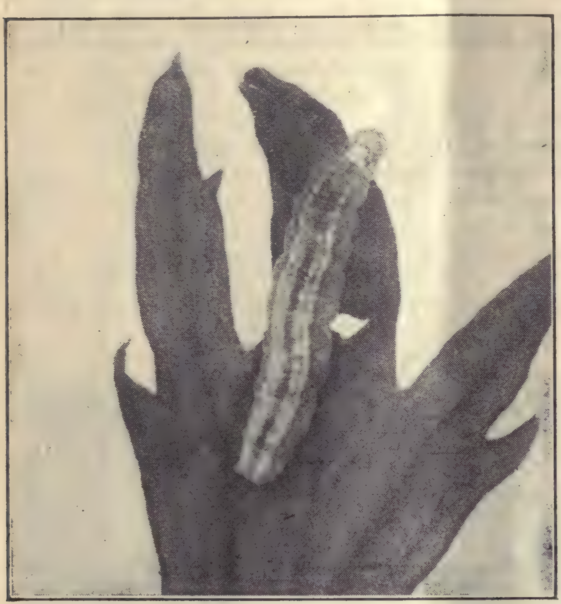

FIG. 5.—Larva of leaf-tyer on chrysanthemum foliage. (Greatly enlarged.)

Young plants may be dipped in a solution of arsenate of lead prepared according to directions on page 24. A thorough coating of the under surface of the foliage where the young caterpillars are feeding is thus insured.

Dusting with a mixture of 9 parts of superfine sulphur and 1 part of calcium arsenate or arsenate of lead by means of a hand blower gun is effective against the larger larvæ. Owing to the fineness of this material it will sift into the fine webbing, reaching the caterpillars more easily than the liquid sprays. Paris green used at the rate of 1 teaspoonful to every 3 gallons of water is also recommended.

In recent experiments it has been demonstrated that the adults can be controlled, without injury to the plants, by fumigation with hydrocyanic-acid gas, using 1 ounce per 1,000 cubic feet for 1 hour.

The Ohio Experiment Station recommends carrying a lighted gasoline torch in one hand slowly through the greenhouse paths, and with the other gently striking a fly swatter or stick against the leaves so as to start the moths into flight. The moths fly into the flame of the torch, burn off their wings, and fall to the ground. An assistant should follow to trample them to death as soon as they fall. As many as 12 to 15 moths have been seen flitting around the flame at one time. Another method of combat recommended is to strike the adults when they swarm against the glass at dusk.

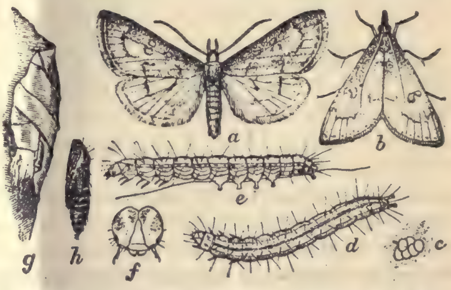

FIG. 6.—The greenhouse or celery leaf-tyer: *a*, Moth; *b*, same in natural position at rest; *c*, egg mass; *d*, larva from above; *e*, same from side; *f*, head of same; *g*, pupa case; *h*, chrysalis. *a*, *b*, *d*, *e*, *g*, *h*, One-half larger than natural size; *c*, twice natural size; *f*, more enlarged. (Chittenden.)

GREENHOUSE WHITE FLY.

As a common and annoying pest to the florist and gardener the greenhouse white fly[3] may easily be placed in the front rank. The white fly attacks especially plants like calendula, primula, ageratum, and coleus, although it feeds on a long list of other flowering and ornamental plants grown under glass. Chrysanthemums are no exception. Instances are known where crops like calendula and ageratum can hardly be grown without remedial measures.

INJURY.

The continual sucking of the plant juices by this insect results in a gradual yellowing of the lower leaves, followed by the higher leaves, which finally dry up and drop to the ground, greatly impairing the health and vitality of the plant. A secondary injury is the excretion of a honeydew or sweetish liquid by the larvæ and pupæ. These droplets fall to the upper surface of the foliage directly below, giving it a glazed appearance and serving as an excellent medium for a sooty fungus which eventually destroys the leaves.

LIFE HISTORY.

Although of tropical and subtropical origin, the white fly is now generally distributed throughout the United States, as well as in Europe. Like aphids, red-spider mites, and scale insects, it obtains its food by sucking the plant juices. The mature white flies are four-winged and hardly more than one-sixteenth of an inch long. Soon after the adult emerges from the pupal case, the entire body becomes covered with a white substance, giving it a characteristic floury appearance, hence the popular name, white fly (Fig. 7). The adult white fly, as well as the scale-like larva, is provided with sucking mouth parts. It lives for a month or longer in this stage, feeding almost continuously. The adult female lays the eggs in a circle while feeding, the beak serving as a pivot, and lays as many as 10 to 20 in each circle.

Feeding is confined usually to the upper and tenderest growth, and invariably to the under surface of the leaf. Here, too, naturally, the eggs are deposited, although they may be found upon the tender leaf petioles or scattered on the upper surfaces of the leaves. They are egg-shaped and are suspended from the leaf by a short slender stalk. On account of their minute size they are hardly discernible to the naked eye. From the eggs, which hatch in from 10 to 12 days under natural greenhouse conditions, flat oval larvæ appear. Even though provided with legs, they crawl only a very short distance from the eggshell, then settle down, and commence to feed by inserting the threadlike beak into the plant tissue. They feed for 5 or 6 days, after which they molt for the first time. The next two stages are much like the first except for size. Each requires from 4 to 6 days. The legs and antennæ now become functionless. When the larvæ attain their full growth they become inclosed in the last or fourth larval skin, in which pupation takes place. In outline the pupæ are similar to the larvæ except that they are thicker, have a boxlike appearance, and are provided with long slender wax rods.

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[3] *Trialeurodes vaporariorum* Westw.

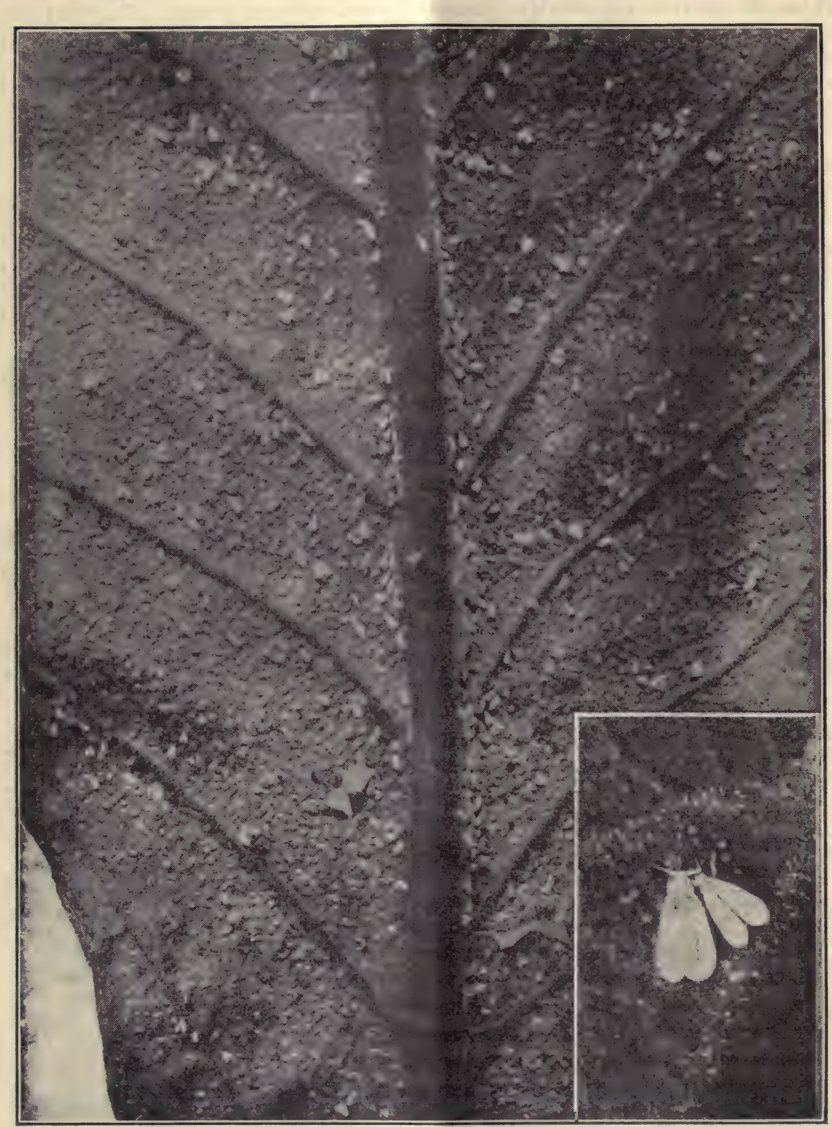

FIG. 7.—Leaf heavily infested with white flies, showing all stages. Insert: Adult male and female white flies.

On emerging from this case a T-like opening appears down the back through which the adult escapes, leaving the glistening white pupa case attached to the leaf. These pupa cases, as well as the living pupæ, are quite conspicuous when present in abundance. Shortly after emergence of the fly, its wings unfold and the development of the insect is complete. The whole cycle, from egg to full-grown adult, requires approximately 5 weeks, viz, egg stage 10 to 12 days, larva 13 to 18 days, and pupa stage 12 to 16 days.

CONTROL.

In the control of this pest advantage is taken of the fact that it requires from 12 to 16 days to complete the pupa stage from which the adult fly emerges. Three or four fumigations with hydrocyanic-acid gas, approximately 10 days to 2 weeks apart, hold this insect in control. The exposure should last only one hour and the dosage employed need not exceed one-half ounce of sodium cyanid per 1,000 cubic feet of space. In this manner the several generations of adults are killed as they emerge, preventing egg deposition for future generations. This is a very reliable and effective means of subduing the white fly.

If fumigation with this gas is inadvisable or the proper facilities are not available, thorough spraying with fish-oil soap solution or the 40 per cent nicotine solution may be employed (see p. 26), preferably preceded by one or two tobacco fumigations.

COMMON GREENHOUSE RED SPIDER.[4]

The common red spider which is distributed throughout the United States is cosmopolitan in its feeding habits. Chrysanthemums, next to roses, violets, sweet peas, and carnations, are frequently severely damaged by this pest. Because of its extremely small size it is more properly designated by the term "spider mite." The full-grown individual (Fig. 8) is about one-fiftieth of an inch long and about half as wide. It is of a reddish color, in general, very frequently tinged with yellow, green, or orange. The body has two dark spots, one on each side, due to the food contents.

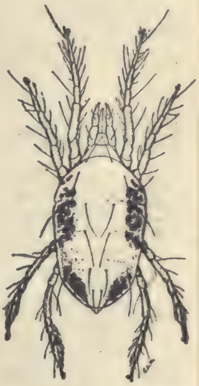

FIG. 8.—The female red spider. Highly magnified. (McGregor and McDonough.)

INJURY.

The red-spider mite injures chrysanthemums by puncturing the foliage with the beak, afterward extracting the liquid contents of the plant cells, surrounding the point of attack. In this manner the green coloring matter is withdrawn, leaving small dead areas and causing the leaves to lose their normal color and later to assume a yellowish lifeless color.

On chrysanthemums the injury is usually confined to the tip growth of the plant, where the most tender foliage is found, causing the development of irregular heads. Flowers that have been attacked are unsalable, as the petals shrivel and become discolored. When the insects are numerous they cover the heads of the plants with their webs (Fig. 9). The amount of damage in greenhouses by the red-spider mites is dependent in a large measure upon the amount of moisture present as well as the nature of the soil. In high temperatures or dry atmospheres they flourish well and they increase in numbers wherever plants are growing in sandy soils.

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[4] *Tetranychus telarius* L.

LIFE HISTORY.

The eggs are deposited on the under surface of the leaf or more often in the webbing which the mites spin. They are very minute, transparent, and resemble dewdrops. Within four or five days after they are laid, minute six-legged larvæ hatch from them, begin feeding almost immediately, and continue to do so for a little over a day. They then fasten themselves firmly to the leaf and enter a resting or premolting stage, which lasts for about a day. After this the skin is shed and an eight-legged creature appears which is called the primary nymph. After feeding for one day the primary nymph enters a secondary quiescent or premolting period, which lasts approximately the same length of time as the larval quiescent stage. A secondary nymph then emerges and is by far the most voracious feeder of the immature forms of these mites. This stage passes through similar feeding and resting periods, each requiring about one day. The full-grown adult female then emerges, establishes herself on the leaf, and feeds for two or three days before she commences egg laying. At this time mating and migration take place. For the next 8 or 10 days eggs are deposited at the rate of 6 per day, making a total of 50 to 60 eggs laid by a single female. In high temperatures the females may live for about 14 days, but in lower temperatures this period is longer. Seven or eight days are required to complete development from egg to adult, making the total life cycle, including the length of the life of the adult, about three or four weeks.

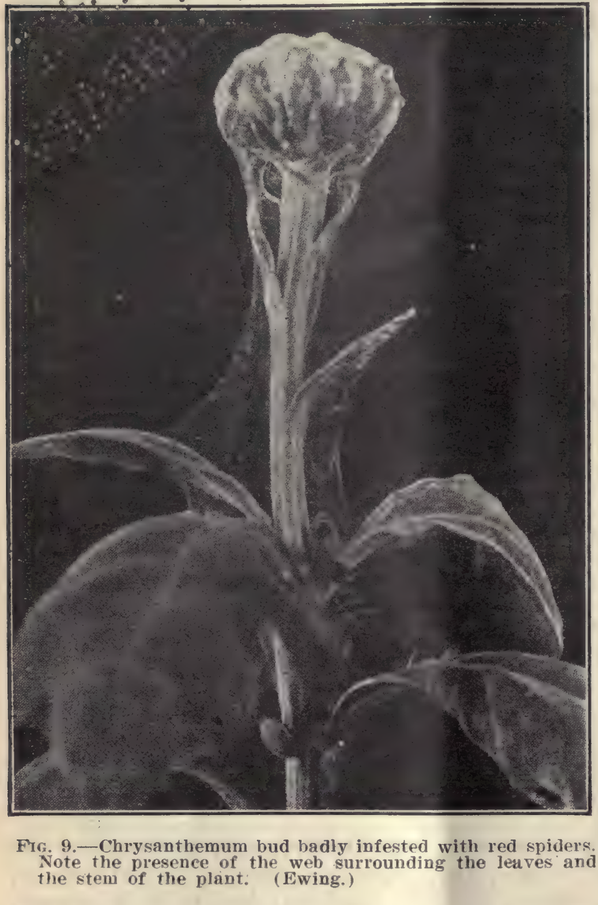

FIG. 9.—Chrysanthemum bud badly infested with red spiders. Note the presence of the web surrounding the leaves and the stem of the plant. (Ewing.)

CONTROL.

Owing to the peculiar structure of the respiratory system of mites, they are very resistant to fumigation with tobacco or hydrocyanic-acid gas, and neither of these fumigants is a practicable means of control.

Frequent syringing with clear water under pressure of at least 25 to 30 pounds is very effective in keeping this pest in check. This operation dislodges the mites, causing them to fall to the ground, where they become lost in the mud. It also disturbs the webbing used by these creatures for egg deposition and protection. Syringing should not be employed on plants that are subject to mildew and can not stand much moisture. Nozzles specially adapted for the purpose should be used to avoid drenching the beds too much, and syringing should be so done as to have the surplus water run off onto the walks. Watering the walks frequently, which keeps the atmosphere from becoming too dry, retards the development of the mites.

Spraying with a warm soap solution prepared by dissolving 1 pound of laundry or fish-oil soap in 4 gallons of water is effective except against the eggs, and should be applied at weekly intervals.

Frequent dusting with superfine sulphur is also very effective in holding the mites in check. This material is best applied by means of modern hand blower guns, several types of which can be purchased.

APHIDS.

Chrysanthemums often suffer severe injury from the attacks of small greenish, brownish, or black aphids or plant-lice. Popularly these insects are occasionally referred to as "lice," "aphids," "black fly," "green fly," etc. The principal injury to these plants is occasioned by the "black aphis"[5] (Fig. 10) and "green aphis,"[6] both of which apparently confine their attack to chrysanthemums.

INJURY.

Aphids are provided with sucking mouth parts with which the plant tissues are pierced and the vital juices sucked up. As a result of the continuous draining of the plant juices, the tender growth becomes stunted and the leaves curl up, causing serious disfigurement and eventually death of the plants. Owing to their small size and concealed position, aphids are frequently overlooked until they have increased to considerable numbers. These insects have a characteristic habit of excreting a sweetish liquid or honeydew which attracts ants, wasps, bees, and flies, and serves as a medium for the development of sooty mold, an objectionable black deposit which reduces or destroys the commercial value of the plants.

LIFE HISTORY.

Aphids differ little in their life history, and a general discussion will suffice for the whole group. They are gregarious in their habits, living in colonies, and are invariably found on the under sides of the leaves and young terminal growth. In these colonies may be found wingless and winged females in all stages of development, from the small newly born to the full-grown individual (Fig. 10). These adults give birth to living young, without fertilization by the male. Under constant-temperature conditions this method of reproduction may continue throughout the entire year. Outdoors and under natural conditions many of the species develop females which lay eggs. The newly born aphids reach maturity in a very short time and in turn give birth to more young. They are prolific and develop very rapidly. A single female may give birth to as many as 100 young at the rate of from 4 to 9 individuals a day. Thus they increase to destructive numbers in a very short period.

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[5] ***Macrosiphoniella sanborni*** Gill.

[6] ***Rhopalosiphum rufomaculata*** Wils.

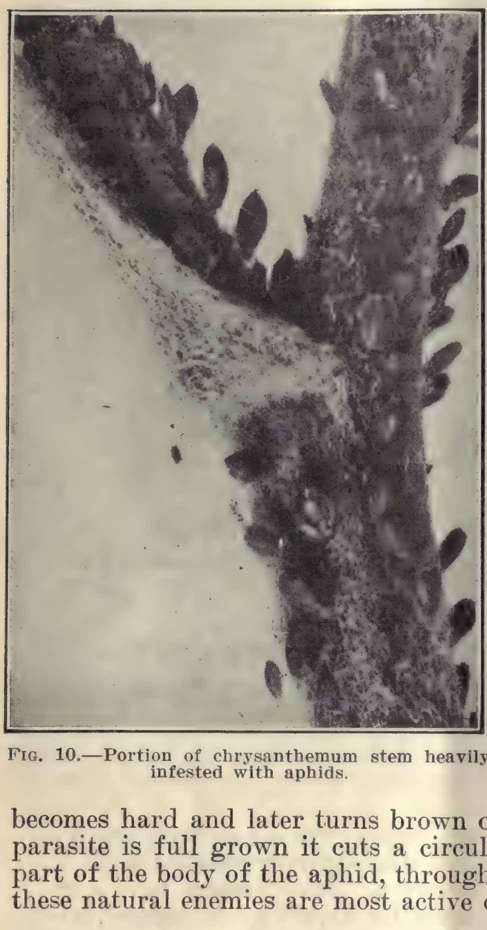

FIG. 10.—Portion of chrysanthemum stem heavily infested with aphids.

NATURAL ENEMIES.

Aphids are kept in check to a certain degree by predacious and parasitic enemies. This, however, should not be construed to mean that no control measures are necessary, because if dependence were placed on natural enemies alone the outcome could not be predicted. The best examples of predacious enemies are ladybird beetles, in both the adult and larva stages. Of the parasites, small wasplike insects, which live within the body of their host, are the most important. A parasitized aphid is easily detected by the fact that the outer or body wall becomes hard and later turns brown or brownish black. When the parasite is full grown it cuts a circular hole through the posterior part of the body of the aphid, through which it emerges. As a rule these natural enemies are most active during warm, dry weather.

CONTROL.

The standard methods of controlling aphids in greenhouses are fumigation with hydrocyanic-acid gas (p. 32), vaporization of nicotine extracts (p. 31), and spraying with contact insecticides (p. 25).

The fumigation with hydrocyanic-acid gas is very practicable, especially during hot weather, when it is inconvenient to smoke with tobacco extracts, which require the house to be closed for a greater portion of the night. With hydrocyanic-acid gas the operation is over in one hour. Even though the temperatures run high, the injury likely to result therefrom would not compare with that from tobacco smoking. The use of hydrocyanic-acid gas is not recommended, however, except in the hands of one fully qualified to handle it, owing to the deadly poisonous character of the gas.

The standard material used for spraying against aphids, either in greenhouses or on outdoor plants, is the 40 per cent nicotine sulphate solution prepared according to the directions given on page 26. Whatever their position on the plants, the insects must be hit or wetted by the spray solution. This is best accomplished, in greenhouses, by using the modern bucket pump, compressed-air sprayer, or knapsack sprayer, equipped with an elbow mist or disk nozzle.

Another satisfactory remedy is to dust the plants early in the morning with dry tobacco dust or commercial preparations containing not less than 2 per cent of free nicotine.

THRIPS.

Chrysanthemums as well as many other ornamental and greenhouse plants are subject to serious injury by minute, slender, active insects properly known as thrips which first rasp the foliage and then suck the juices. Other portions of the plant, as the tender new growth, buds, and flowers, are not immune from their attack. Several species of thrips are concerned, of which two or more may be found simultaneously on the same plant.

On chrysanthemums the greenhouse thrips, the onion thrips, the flower thrips, and the sugar-beet thrips are most frequently intercepted. Thrips belong to a quite distinct order of insects whose mouth parts differ from those of other insects by being intermediate in structure between those of chewing and sucking insects. The several species just mentioned are much alike in their feeding habits and general structure, and a discussion of one form, the common greenhouse thrips,[7] will give a fair idea of the whole group.

DESCRIPTION AND LIFE HISTORY.

The adult greenhouse thrips is minute in size, being about one-twenty-fourth of an inch long. In general it is of a dark brown color, the tip of the body being much lighter. It is provided with two pairs of featherlike wings (Fig. 11). The eggs are laid in the leaf tissue by the adult female while feeding. Under greenhouse conditions the eggs hatch out minute white larvæ about 8 days after deposition. During the period of growth, which requires from 10 to 20 days, these white larvæ feed actively in colonies, causing the same type of injury as is done by the full-grown adults. At the completion of this stage the full-grown larvæ change to the prepupa and pupa or resting stages, during which time no food is taken. These stages require from 4 to 6 days, after which the fully developed adult thrips emerges. A generation is therefore completed in from 20 to 33 days, and under greenhouse temperatures many generations occur throughout the year.

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[7] *Heliothrips haemorrhoidalis* Bouché. The onion thrips is *Thrips tabaci* Lind.; the flower thrips, *Frankliniella tritici* Fitch; the sugar-beet thrips, *Heliothrips femoralis* Reuter.

INJURY.

The greenhouse thrips confines its damage almost entirely to the foliage. Both adults and larvæ obtain their food by piercing and rasping the leaf surface, and after lacerating the tissue the plant juices are sucked out, leaving a white spot at the point of attack. In the beginning these spots show more plainly on the lower surface. As attack continues the spots coalesce, forming blotches and resulting in dead areas and a final wilting and dropping off of the foliage.

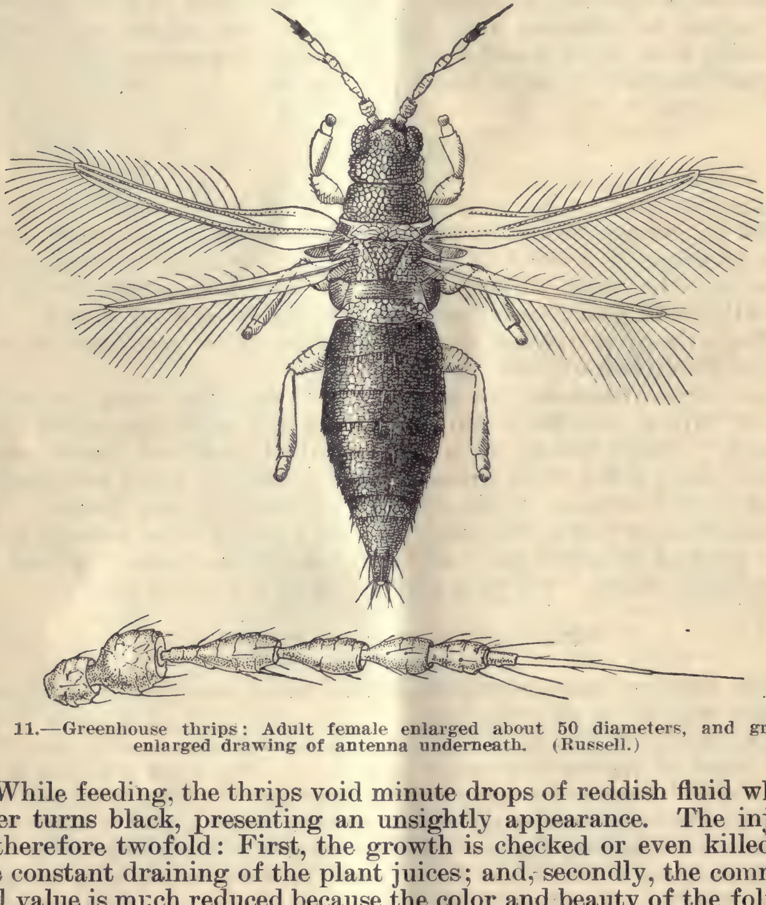

Fig. 11.—Greenhouse thrips: Adult female enlarged about 50 diameters, and greatly enlarged drawing of antenna underneath. (Russell.)

While feeding, the thrips void minute drops of reddish fluid which later turns black, presenting an unsightly appearance. The injury is therefore twofold: First, the growth is checked or even killed by the constant draining of the plant juices; and, secondly, the commercial value is much reduced because the color and beauty of the foliage for ornamental uses is spoiled by their feeding and the black discoloration due to the fluid they exude.

CONTROL.

Essentially the same measures may be employed for thrips as are used against the aphids, viz, fumigation with hydrocyanic-acid gas, tobacco smudges from the liquid extract or from paper impregnated with it, spraying with contact insecticides, and dusting the foliage with superfine tobacco dust.

CUTWORMS.

The general term "cutworms" designates the larvæ or young of many forms of night-flying moths which are all more or less similar in general appearance and habits. Annually these insects cause extensive loss through their depredations to crops throughout the United States. The commonest greenhouse species, the variegated cutworm,[8] feeds primarily on chrysanthemums, carnations, smilax, sweet peas, asparagus, and violets. Entrance to greenhouses probably is gained either by the moth flying in through the ventilators and depositing her eggs on the plants, or in the larva stages in the soil when the benches are being filled with sod.

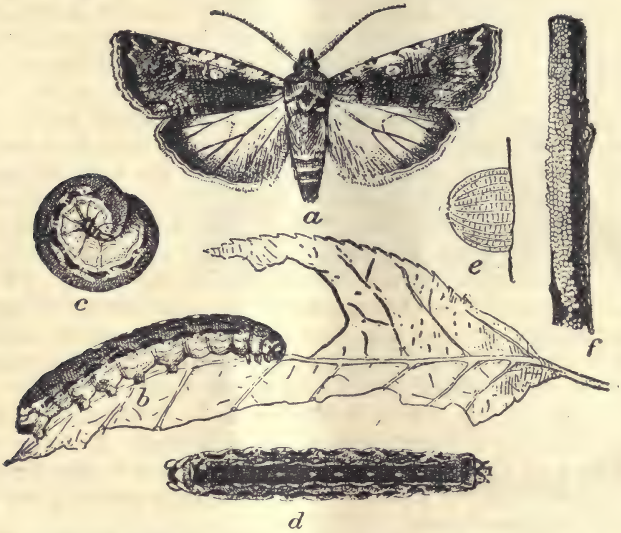

FIG. 12.—Variegated cutworm: *a*, Moth; *b*, normal form of caterpillar, side view; *c*, same in curved position; *d*, dark form, view of back; *e*, greatly enlarged egg, seen from side; *f*, egg mass on twig. (Howard.)

INJURY.

The variegated cutworm in greenhouses, in addition to the usual cutworm habit of cutting off young plants near the surface of the soil, or severing the stems a little higher, as well as feeding on the tender leaves of plants more advanced in growth, attacks the flower buds of chrysanthemums and carnations, in particular, and eats out the centers, thus spoiling the blossoms. All stages of development may be found throughout the year under greenhouse conditions, although their ravages are likely to occur mostly in the spring months and continue throughout June and July. When present in large numbers, they may cause considerable injury before their presence is detected. Owing to their large size when full grown, these caterpillars often destroy more plants in a single night than they can devour.

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[8] *Lycophotia margaritosa* Haw.

LIFE HISTORY.

The eggs (Fig. 12, *e*, *f*) of the variegated cutworm are laid at night by the parent moth or miller, mostly on the under sides of the leaves or in rings about the stems, and are about one-fiftieth of an inch in diameter. They are globular, strongly ribbed, and creamy white when first laid but become darker just before hatching. From 200 to 500 eggs are deposited by a single female moth in masses of 60 or more. These eggs hatch out small larvæ in 5 or 6 days, and these begin feeding almost immediately on any succulent growth available. Because of their night-feeding habit they are rarely seen in the daytime. On close examination of the soil at the base of plants or under débris about the beds the various stages may be found from the small to the smooth, full-grown, robust, soft-bodied, cylindrical caterpillars, about 1½ inches long, varying in color from pale or dirty gray to nearly black and spotted with a row of four to six yellow spots down the middle of the back. (Fig. 12, *b*, *c*, *d*.) The caterpillar reaches maturity in about 25 to 30 days, after which it enters the ground and forms an earthen cell in which transformation to the reddish brown pupa takes place. This stage takes from 15 to 20 days, after which the adult moth or miller emerges. The moth (Fig. 12, *a*), which is brownish in color and marked with black mottlings, has a wing expanse of 1¾ inches. It lives for about 7 to 10 days and during this period the eggs are deposited. The whole life cycle requires from 45 to 54 days, depending on the temperature of the greenhouse.

CONTROL.

Cutworms are easily controlled by using a poisoned bait made up of bran, alfalfa meal, or middlings as a basis, the formula for which is given on page 25.

Since the cutworms feed at night or on dull cloudy days, and as the bait is more attractive when fresh, it should not be applied until evening or at dusk. Scatter the mash sparingly about the bases of the plants, repeating several times at intervals of 3 or 4 days if they reappear.

Spraying or dipping the plants in a solution of lead arsenate such as is used for other chewing insects is quite effective, especially for small plants. (See p. 24.) When only a few are present, hand picking may be practiced.

PREVENTION.

Soil brought into the greenhouse should first be sterilized by steam or cleared of cutworms by the poisoned bait.

SCALE INSECTS.

Several forms of scale insects occasionally become serious pests on chrysanthemums. The greenhouse Orthezia,[9] the hemispherical scale,[10] and mealybugs,[11] are the most troublesome. They migrate to chrysanthemums from neighboring plants which are infested. Being provided with sucking mouth parts, they sap the vital fluids of the plants, causing a loss of color, wilting, and eventual death of the affected parts, if not controlled.

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[9] *Orthezia insignis* Dougl.

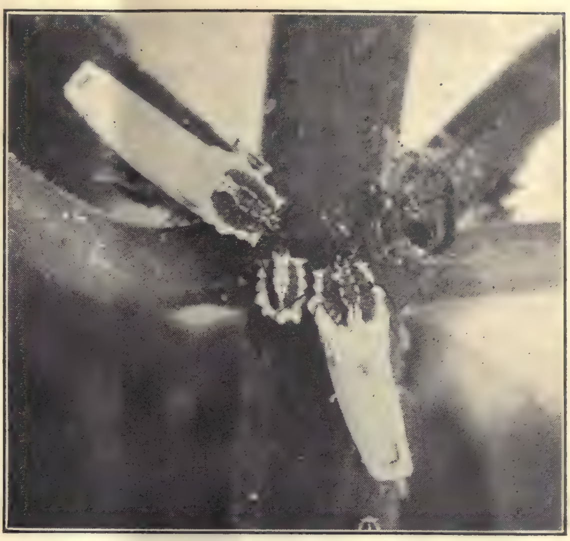

FIG. 13.—Greenhouse Orthezia on stem of plant.

THE GREENHOUSE ORTHEZIA.

The adult female of the greenhouse Orthezia (Fig. 13) is elongate, scalelike in appearance, with prominent long legs, and about one-twelfth of an inch long. The bare upper front portion of the body is olive green and covered with waxlike plates. A characteristic of the female is the white cylindrical egg sac which projects from the hind end of the body and is frequently much larger than the latter. The young hatch within this sac and then crawl out of an opening at the hind end. After this they may be found moving about actively on any part of the plant. When first born the body is devoid of the waxy plates, but it is soon completely enshrouded within them. The males, which are two-winged, are rarely seen. The adult female lives about four months. The entire cycle requires about six months, hence there may be two generations annually.

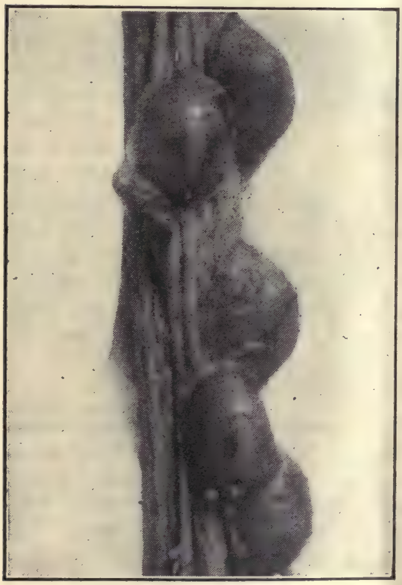

FIG. 14.—Hemispherical scales on stem of plant.

THE HEMISPHERICAL SCALE.

While primarily an obnoxious fern pest, the hemispherical scale (Fig. 14) frequently infests chrysanthemums and causes considerable injury. As the specific name indicates, this scale insect is hemispherical, very convex, smooth and shiny, with flat edges. The color varies from a light to a dark brown and the insect is a little more than three-eighths of an inch long and its width is a trifle less. It reproduces by means of eggs which are deposited beneath the scale.

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[10] *Saissetia hemisphaerica* Targ.

[11] *Pseudococcus citri* Risso; *P. adonidum* L.

THE MEALYBUGS.

In general mealybugs are characterized by an oval or elongate body, which is more or less coated with a white mealy secretion. The body margins have protrusions of white waxy filaments which distinguish the two more common greenhouse species from each other. In the case of the short-tailed mealybug, none of the filaments are nearly as long as the body, while the long-tailed mealybug has four marginal filaments or tassels extending from the hind end like a long tail. These are about as long as the body. The short-tailed mealybug is the larger of the two. The eggs are laid by the female in a protective mass of waxlike webbing or secretion under the tip of the abdomen. They are usually found in clusters and multiplication is very rapid, as each female may lay from 300 to 500 eggs. Egg-laying continues for a period of about 10 days and from 20 to 30 eggs are laid daily by each individual female. The eggs hatch in 14 days and the larvæ are much like the adults except for their smaller size and being devoid of the wax secretion. All stages are present at the same time, and they may be found on the plants throughout the year. Their usual place of abode is on the under side of the leaf, along the veins and ribs, and in crevices at the base of the petiole.

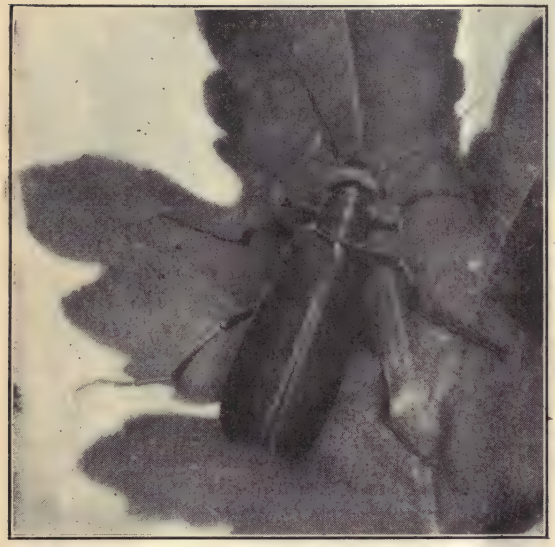

FIG. 15.—Adult of the margined blister beetle (*Epicauta marginata*).

CONTROL.

Syringing with clear water under pressure in the same manner as is recommended for red-spider mites is probably one of the most effective methods of control for mealybugs. For all scale insects spray frequently, using fish-oil soap or nicotine-soap solution prepared as directed on page 26, or place poisoned honey bait (see formula on p. 20) about the greenhouse or garden to kill the ants which attend them. In general, ants are the first consideration in control of mealybugs and scale insects. Fumigate with hydrocyanic-acid gas (p. 32).

OCCASIONAL PESTS.

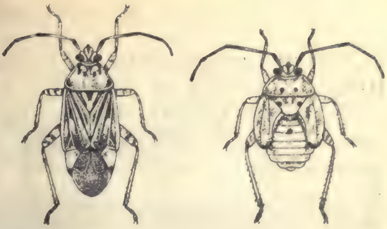

Fig. 16.—The tarnished plant-bug: Adult stage at left; last stage of nymph at right. Enlarged nearly four times. (Chittenden.)

In addition to the insects treated before, several species of both leaf-eating and sucking insects occasionally injure chrysanthemums. Among the most frequently intercepted of the leaf-eating group are grasshoppers, blister beetles (Fig. 15), rose beetles, the larvæ of the burdock or chrysanthemum leaf-miner[12] and of the marguerite fly,[13] and various forms of caterpillars, such as the corn earworm,[14] European corn borer,[15] cabbage looper,[16] and "yellow bear."[17] In the sucking group may be mentioned primarily the plant-bugs (Figs. 16, 17), leafhoppers, and the lace-winged leaf-bugs. By spraying with an arsenate of lead solution to which nicotine sulphate has been added, both types of insects mentioned above can be effectively held in control.

Aside from the pests named above, ants, termites (white ants), white grubs, slugs, snails, sowbugs, and millipeds may, at times, cause injury to both indoor and garden-grown chrysanthemums.

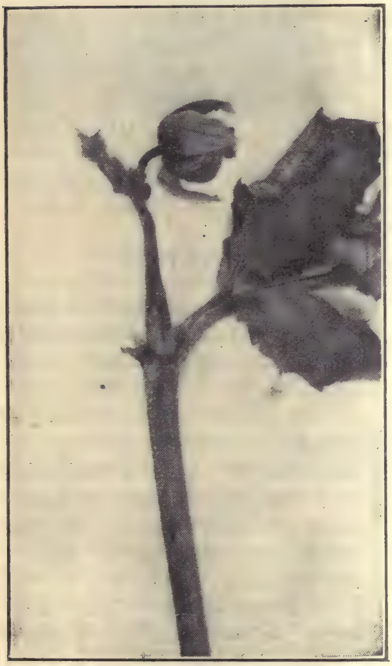

Fig. 17.—Bud and tip injury by the tarnished plant-bug to chrysanthemum.

ANTS.

Ants frequently become very troublesome by building their nests and galleries under the roots of plants or directly in the pots. Their presence in greenhouses is usually an indication that some of the plants are infested with one or more species of honeydew-producing insects, such as mealybugs, soft scales, aphids, etc. Ants protect these insects from natural enemies, transfer them from time to time to young succulent growth, and build shelters for their protection. (Fig. 18.) They collect and transfer to their nests the honeydew or sweet fluid excreted by the insects. This habit of the ants is taken advantage of in the use of poisoned bait.

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[12] *Agromomyza maculosa* Malloch.

[13] *Phytomyza chrysanthemi* Kowarz.

[14] *Heliothis obsoleta* Fab.

[15] *Pyrausta nubilalis* Hübn.

[16] *Autographa brassicae* Riley

[17] *Diacrisia virginica* Fab.

CONTROL.

Recent experiments have demonstrated that ants can be satisfactorily controlled by using the following poisoned sirup as a bait:

Take granulated sugar, 15 pounds; water, 7½ pints; and tartaric acid (crystallized), ¾ ounce. Boil these ingredients slowly for 30 minutes and allow to cool. Then dissolve three-fourths of an ounce of sodium arsenite ($NaAsO_2$) in one-half pint of hot water and allow to cool. Combine the two solutions by thorough stirring. Finally add 1½ pounds of honey. Saturate small pieces of sponges with the poisoned sirup and distribute about the infested places sheltered with inverted thumb pots placed over them. The ants convey this material to their nests and die as a result of feeding on it.

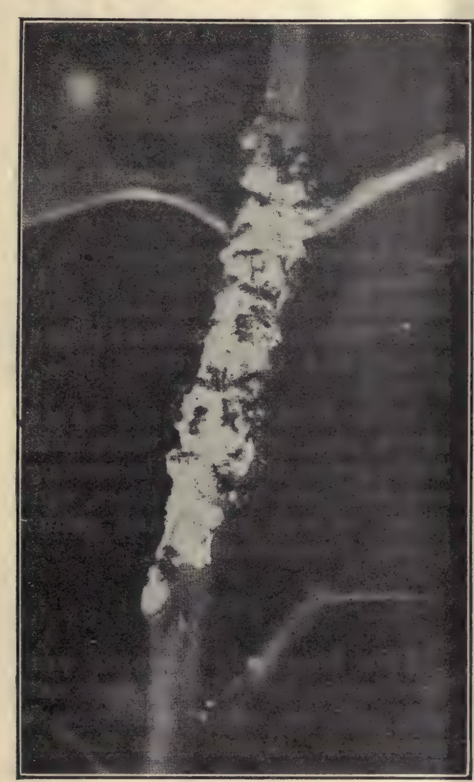

FIG. 18.—Ants attending a group of mealybugs. Their almost constant presence protects the mealybug from its natural enemies. (Woglum and Borden.)

Spray walks, soil under pots and benches, and woodwork with kerosene nicotine oleate (p. 26).

TERMITES.

Termites or white ants (Fig. 19) are occasionally reported as injuring chrysanthemums and other greenhouse plants. These insects come up through the ground or burrow up through the wooden bench legs and form dirt galleries over the supports, or run galleries the entire length of the wooden benches (Fig. 20). They injure and kill the plants very quickly by eating out the main stock of the root. Termites gain entrance to potted plants through the drainage holes, and in case of bench plants they work their way up directly through the woodwork in which they have their nests.

CONTROL.

In the case of potted plants or benches which can not be immediately replaced, soak the ashes or sand under the pots of the infested benches with a 5 per cent solution of kerosene emulsion, or with kerosene nicotine oleate (p. 26), or a solution of 1 ounce of sodium cyanid dissolved in each gallon of water. Carbon disulphid, which is a very volatile liquid, may be used in moist soil which is more compact. This is more easily applied by punching a hole near the base of the plants, pouring in the liquid, and immediately covering it with earth, so as not to allow the gas to escape.

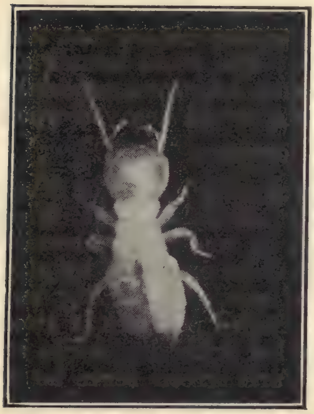

FIG. 19.—Mature "worker" of the white ant known as *Reticulitermes flavipes*; etherized specimen. Enlarged nearly seven times.

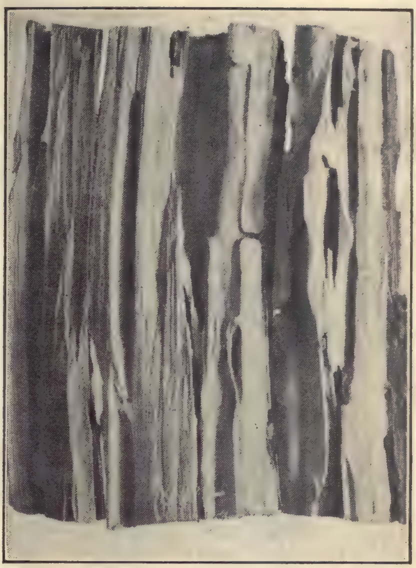

FIG. 20.—Work of white ants. (Snyder.)

In severely infested greenhouses, the entire infested woodwork should be removed and replaced, preferably by upright steel frames set in concrete bases. If it is necessary to use wooden uprights, they should be set in concrete or rest on stones or bricks above the surface of the ground.

WHITE GRUBS.

The larvæ of May beetles or "June bugs" (Fig. 21) are frequently introduced into greenhouses when the benches or beds are being refilled with composted sod. Outdoors they are frequent pests. They feed primarily on the roots, causing the plants to wilt and eventually die.

CONTROL.

Pour 1 ounce of carbon disulphid into a hole in the soil about 8 inches from the base of the plant and quickly cover up by tamping down the soil over it. As this material is very inflammable, keep it away from lights and fires. Sterilize the soil, if heavily infested, before filling benches or beds.

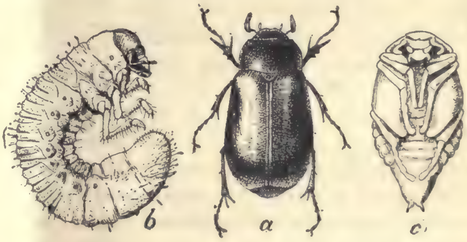

FIG. 21.—A white grub, or May beetle: *a*, Beetle; *b*, larva or grub; *c*, pupa. Enlarged one-fourth. (Chittenden.)

SLUGS AND SNAILS.

In greenhouses and gardens slugs[18] and snails are often insidious pests. They usually confine their attack to young tender seedlings, which they devour, although the large plants are not immune from their attacks. In size they are from one-half inch to 4 inches long, and their colors vary from a yellowish gray or brown mottled with black, to dark gray and black (Fig. 22). A sticky mucous secretion is exuded from their bodies, which adheres to any object that they crawl over, leaving glistening trails behind. The usual haunts are in dark and damp locations, especially under flowerpots or old decayed wood.

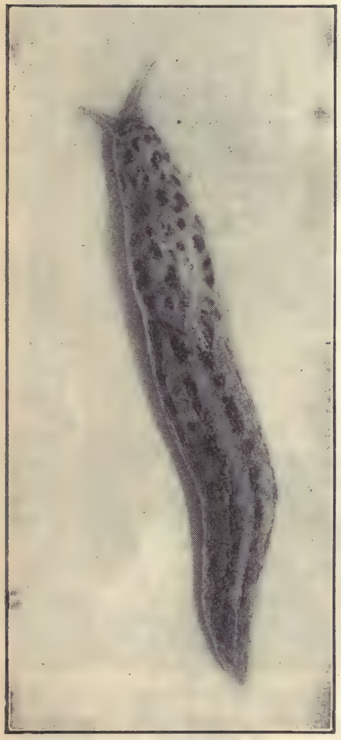

FIG. 22.—The spotted garden slug. (White.)

CONTROL.

Remove all decaying boards or débris and then apply air-slaked lime, finely pulverized salt, or road dust liberally. Cutting beds may be protected by placing a border of salt, soot, or dry lime around them. Boiled potatoes or sweet potatoes sprinkled with dry white arsenic or dry Paris green serve as an effective bait. Saturate the soil with mercuric chlorid solution (p. 27).

SOWBUGS OR "PILLBUGS."

Sowbugs are very active on being exposed to light, although some forms roll themselves up into the shape of a round pill on the least disturbance, and are therefore spoken of as "pillbugs." They are dark gray and have oval, flattened bodies. They are not true insects. Their usual place of abode is under some such shelter as decayed boards or flowerpots, in decaying manure, or in any dark moist place where decay is in progress. Cutting beds are preferred by them, although they feed on roots and tender portions of older plants.

CONTROL.

Sprinkle the surface of the soil lightly with a dry mixture consisting of 9 parts of sugar and 1 part of dry Paris green. A similar remedy may be substituted which is prepared as follows:

White flour	2 parts.
Sugar	2 parts.
Paris green	1 part.

Apply in the same manner as the preceding mixture.

Dry tobacco dust is very repellent to sowbugs. Kerosene nicotine oleate (p. 26) is also very effective.

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[18] The spotted garden slug (*Limax maximus* L.) is treated in Farmers' Bulletin 959.

MILLIPEDS.

These hard-shelled wormlike creatures are often called "thousand-legged worms." They are distinguished from nearly related forms by having two pairs of legs on each body segment except the first three. Primarily they injure the roots, although the stems of plants are frequently attacked. Usually they are associated with manure which contains considerable decaying vegetable matter, and they are abundant in damp places, especially under flowerpots.

CONTROL.

Vegetables dipped in dry Paris green or in dry lead arsenate and placed about the benches are a very effective remedy. Drenching the soil with a solution of one-half ounce of mercuric chlorid to 3 gallons of water (p. 27) or with kerosene nicotine oleate (p. 26) also operates against them. Dry Paris green and sugar (1 to 9), as recommended for sowbugs, is also very effective.

PREPARATION OF INSECTICIDES.

The use of chemicals in some form of spray or by fumigation for the control of insect pests is now recognized as a standard practice. Practical and intelligent employment of these chemicals or insecticides depends upon an accurate knowledge of the manner in which the insects feed. The fundamental question is whether the insect is provided with chewing or sucking mouth parts. Insects of the chewing type bite off and swallow portions of the plant tissues and require that stomach poisons, such as the arsenicals, be applied to the plants. Cutworms, leaf-tyer larvæ, beetles and their grubs, crickets, grasshoppers, etc., are examples of this group. The sucking insects, on the other hand, are not affected by stomach poisons, because they are provided with a beak which they thrust down through the outer layers of the leaves into the soft, succulent tissues beneath and by means of which they extract the vital juices. Substances must therefore be used which come into contact with the insect's body and which kill by exerting a caustic action on the body tissues, by smothering the insect with poisonous fumes given off from the insecticides, or by entering the breathing pores and closing them or causing paralysis by their effect upon the insect's nervous system. Insects to be treated in this manner include aphids, thrips, and scale insects. Frequently deterrent substances are used which repel the insects.

Briefly, the chemicals used as insecticides may be placed in three classes, viz, stomach poisons, which are applied to the plants and devoured with the portions of the plants upon which the insects feed; contact sprays, which are applied to the insects, and incidentally to the plants, because one can not be hit without hitting the other; and fumigants, which fill the entire atmosphere with gaseous fumes and suffocate the insects. Hydrocyanic-acid gas and tobacco extracts are the best examples of the last class.

STOMACH POISONS.

ARSENATE OF LEAD.

2 pounds (powdered) to 50 gallons of water or fungicide.
⅔ ounce or 10 level teaspoonfuls to 1 gallon of water or fungicide.

Arsenate of lead as a liquid spray is probably the most extensively used of the stomach poisons and can be obtained commercially in either the paste or the powdered form. The latter is to be preferred owing to the lighter weight and greater convenience in handling. Arsenate of lead can be used safely on chrysanthemum plants at the foregoing strength. It possesses good adhesive qualities and can easily be combined with certain contact insecticides and fungicides. It will operate against almost all forms of caterpillars, cutworms, leaf-tyers, and leaf-rollers, many adult beetles, and other insects which feed on the foliage.

In preparing an arsenate of lead spray the material should first be made up in a thin paste by the addition of a small quantity of water and then diluted to the required strength. On smooth foliage or leaves with a waxy surface the liquid does not stick or spread well. This difficulty is easily overcome by adding a "sticker" such as fish-oil soap or any common laundry soap at the rate of 2 pounds to 50 gallons of liquid. For smaller quantities use from one-half to 1 ounce for each gallon of spray. Objection is frequently made to the use of arsenate of lead in the form of liquid spray because of the deposit which remains on the foliage. This should not be a prime consideration, however, because it is usually the younger plants that require the spray, and the leaves affected are left behind as the plants grow.

Arsenate of lead also finds a limited use in poisoned baits for sowbugs, cutworms, etc. Pieces of fresh-cut vegetables are dusted with the powder, or clover is dipped in a strong solution. The powdered form when combined with other ingredients such as tobacco dust, or superfine sulphur, with lime as a filler, and dusted on by means of a modern hand blower gun, serves as a combined stomach and contact poison.

CALCIUM ARSENATE.

Calcium arsenate, or arsenate of lime, can be substituted for lead arsenate for the control of leaf-eating insects on chrysanthemums. Its use, however, has not been fully demonstrated, although the writer proved in preliminary tests that as a dust it does not injure the foliage. Owing to its fineness it is admirably suited for dusting when combined with superfine sulphur.

PARIS GREEN.

5 to 6 ounces to 50 gallons of water; 1 pound of lump lime.
1 teaspoonful to 3 gallons of water; 2 to 3 ounces of lump lime.

Paris green is an arsenical compound which has been widely used by florists in the past but is now gradually falling into disuse owing to the danger of burning the tender foliage and plants. It is difficult to keep it from settling and the solution has to be constantly agitated during spraying. It is probably better as a poisoned bait for cutworms, sowbugs, slugs, millipeds, etc., when 1 part of Paris green is mixed dry with 9 parts of sugar and sprinkled over the soil. Its use as the active ingredient of poisoned bait for the control of cutworms and grasshoppers is discussed under the heading "Poisoned Bran Mash."

When applied as a spray it insures almost complete control of the black aster beetles[19] which frequently attack chrysanthemums.

WHITE ARSENIC.

This is a very active stomach poison but its use on foliage is precluded because of the severe burning likely to follow. It is finding increasing use in poisoned baits as a substitute for Paris green because it is somewhat cheaper.

POISONED BRAN MASH.

Dry ingredients:	
Paris green or white arsenic	¼ pound.
Dry bran, alfalfa meal, or middlings	1 peck.

Liquid ingredients:	
Sirup or molasses	1 pint.
Water	4 to 6 quarts.

6 to 8 oranges or lemons.

As well as being an excellent remedy for grasshoppers, in general, this poisoned bait is now serving as an effective poison for the control of cutworms. The white arsenic and dry bran are first mixed thoroughly together in a vessel. In another vessel stir a pint of cheap molasses or sirup into from 4 to 6 quarts of water. Then prepare a mash by slowly adding the liquids to the poisoned bran. Allow the mash to stand for several hours for the bran to take up the arsenic. Lemons or oranges finely ground up are sometimes added to make the bait more attractive.

HELLEBORE.

Liquid:	
Hellebore	1 ounce.
Water	1 gallon.

Dry:	
Hellebore	1 ounce.
Flour or air-slaked lime	5 to 10 ounces.

This material is employed only where few plants are concerned. It is a powder made from the roots of the white hellebore plant, and may be used either as a dust or in solution, being effective against very young larvæ of many leaf-feeding insects.

CONTACT INSECTICIDES.

Tobacco or nicotine solutions are very generally used for the control of many soft-bodied sucking insects, and florists find them particularly valuable against aphids, thrips, rose slugs, etc. They are recognized as standard contact sprays, and can be purchased as liquid concentrates under many proprietary names either in the volatile or in the nonvolatile form. They are easily diluted to the required strength or may be combined with many standard stomach poisons and fungicides.

VOLATILE NICOTINE.

The volatile or free nicotine as a liquid is largely used for fumigation purposes by painting it on the steam pipes or by vaporizing it over lamps. It is also used for spraying, but not to such a great extent as the stable forms. Directions for its use are given on the labels of the containers in which it is purchased.

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[19] *Epicauta pennsylvanica* DeG.

NONVOLATILE TOBACCO OR NICOTINE EXTRACTS.

1 to 1¼ teaspoonfuls to 1 gallon of water.
1 fluid ounce to 8 gallons of water.
¼ pint or 4 ounces to 25 gallons of water.
Add soap at the rate of 1 ounce per gallon of solution.

The nonvolatile extract is most extensively used, comes prepared in a highly concentrated form, and should contain not less than 40 per cent of nicotine sulphate. When tobacco solutions are used alone, soap is usually added to enhance the adhering qualities.

Preparation: First heat the water, then dissolve the desired amount of fish-oil or common laundry soap in the water after shaving it into fine particles. When the soap is thoroughly dissolved, add the necessary amount of tobacco extract and apply while hot or warm. This prevents solidifying and clogging of the apparatus, especially when a fine mist spray is desired. Apply late in the afternoon or on cloudy days to prevent unnecessary burning from sunlight. Spray with the first indication of the insects, in order to prevent occurrence of a later severe infestation.

TOBACCO DUST.

Tobacco dust, applied by means of a modern hand blower gun, is effective in destroying thrips and aphids. It may be used in the pure undiluted form or mixed with a carrier such as superfine sulphur, arsenate of lead, lime, or flour, at the rate of 5 parts of tobacco dust to 5 parts of superfine sulphur, lime, or flour. But when 1 part of arsenate of lead is added for the control of leaf-eating insects, 4 parts of tobacco dust and 5 parts of the carrier may be used.

SOAP SOLUTION.

Fish-oil or hard soap	1 pound.
Water	2 to 4 gallons.

A soap solution prepared by simply dissolving either fish-oil soap or common laundry soap in water serves as a "sticker," and also as a satisfactory remedy for aphids, immature scale insects, and red spiders. When used in the more concentrated forms it should be applied while still warm, otherwise it is likely to become stiff or gelatinous. It is advisable to syringe the plants with water the day following the application. Care should also be exercised not to allow the soap solution to collect in the soil in which the plants are growing.

KEROSENE NICOTINE OLEATE.

Stock solution:	
Solution No. 1—	
Kerosene	8 parts or 1 gallon.
Oleic acid	1 part or 1 pint.
Solution No. 2—	
Volatile nicotine	2 parts or 2 pints.
Water	8 parts or 1 gallon.

Solution No. 1 is prepared by slowly pouring the oleic acid into the kerosene, stirring constantly. In another vessel make up solution No. 2 by adding the volatile nicotine to the water. The stock solution is then prepared by stirring solution No. 1 into solution No. 2 and the mixture brought to a creamy consistency by rapidly churning it for several minutes, pouring from one vessel to the other or pumping the liquid back upon itself through a bucket pump.

For use against sowbugs, earthworms, ants, millipeds, etc., dilute the stock solution 1 pint to 10 or 12 gallons of water and spray thoroughly the ashes or sand under the pots or the soil underneath the benches as well as the walks and woodwork. Avoid getting too much of this material on growing plants.

MERCURIC CHLORID SOLUTION.

½ ounce dissolved in 3 gallons of water.

Mercuric chlorid is also known under the names bichlorid of mercury and corrosive sublimate. It acts as a contact insecticide against earthworms, slugs, snails, and the immature forms of certain soil insects, such as the larvæ of fungus gnats, when the soil in which they occur, either in the pots or beds, is drenched with a solution at the strength indicated above.

As *this chemical is a deadly poison*, the greatest care should be exercised in its preparation and handling, as well as in cleaning the vessels used. Since the bichlorid corrodes metals, it is desirable to prepare it in a glass or glazed vessel.

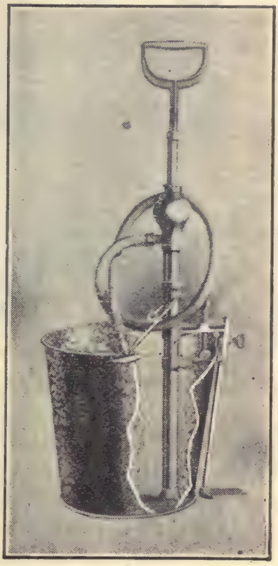

FIG. 23.—Bucket pump. (Quaintance and Siegler.)

METHODS OF APPLYING INSECTICIDES.

SPRAYING AND DUSTING.

The prime considerations for the application of insecticides in general are promptness and thoroughness. The next is an apparatus which will break up the liquid into a fine mistlike spray and insure an even coating over the plant surfaces to which it is applied. The leading features of such an apparatus are the force pump, hose or tubing, and nozzles.

For use in the greenhouse, when only a few plants are concerned, the hand atomizer is very convenient. The bucket pump (Fig. 23) and the compressed-air sprayer (Figs. 24 and 25), however, are most suitable, the latter being preferable. Compressed-air sprayers have a capacity ranging from one-half gallon to 3 or 4 gallons, and are very practical for bench work. For large establishments outfits with a capacity of from 5 to 25 gallons, mounted on one wheel (Fig. 26) or two wheels (Fig. 27) are very desirable, as they can be wheeled throughout the houses and if necessary two leads

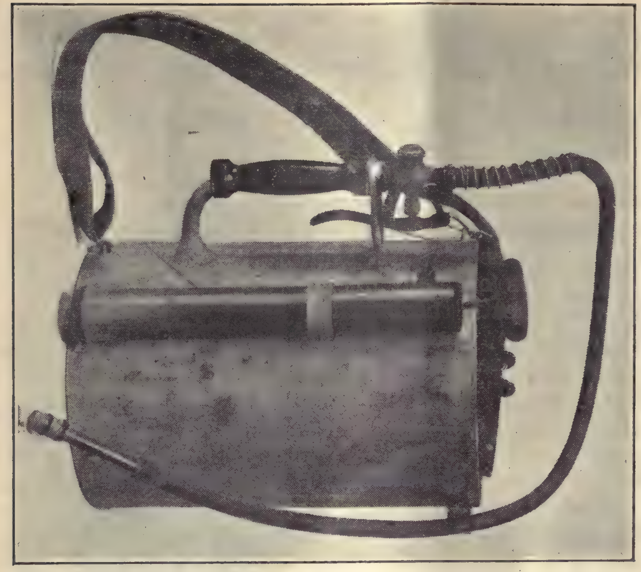

FIG. 24.—One of several kinds of compressed-air sprayers. (Chittenden.)

of hose may be used at one time.

It is well to observe when purchasing equipment of any type that it is so constructed as to permit easy replacement of parts likely to wear out quickly, such as the valves. The spray hose should be about three-eighths to one-half inch in diameter and of the best high-pressure type. The length will naturally vary according to conditions, although the 25 to 50 foot lengths are very desirable. A hose reducer (Fig. 28) attached to the end of a hose with a cut-off coupled to the other end of the reducer is very handy because it serves as a device or control for cutting off the spray material whenever necessary and allows the further attachment of either a spray rod or a nozzle. The spray rod so attached will be found very practical for spraying garden plants, or for plants in ground beds or on wide benches in the greenhouse, and for syringing in general.

The nozzles should be preferably of the angled type and should deliver an even, cone-shaped spray. Two types of nozzles adapted for greenhouse and gen-

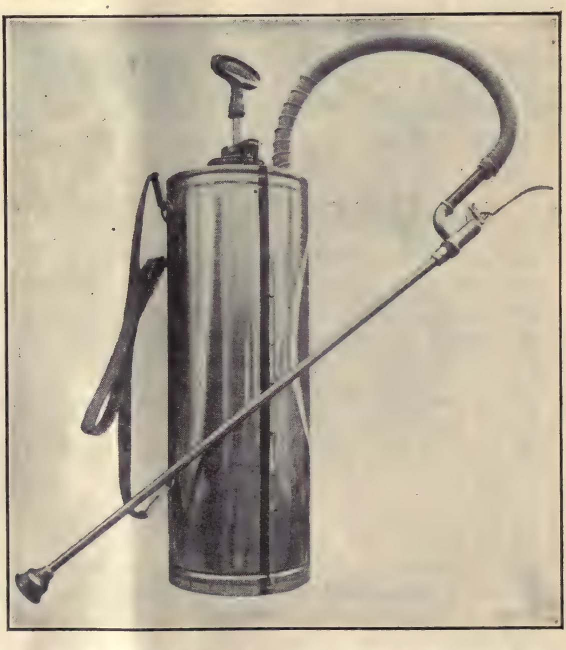

FIG. 25.—Compressed-air sprayer for small spraying operations. No pumping is required while spraying. (Quaintance and Siegler.)

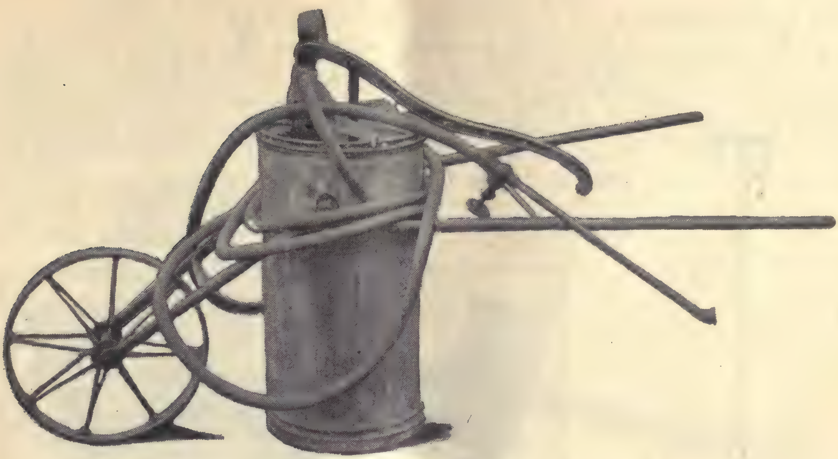

FIG. 26.—Barrow type of sprayer for greenhouse use.

eral spraying are illustrated in Figures 29 and 30. A straight nozzle may easily be connected to an angled type by using a 45° angle connection (Fig. 30).

Several types of the modern hand dust guns are now being used by many florists where dusting is substituted for liquid spraying (Figs. 31 and 32).

Other considerations for efficient control are the correct proportions of the ingredients in the preparation of the insecticide and

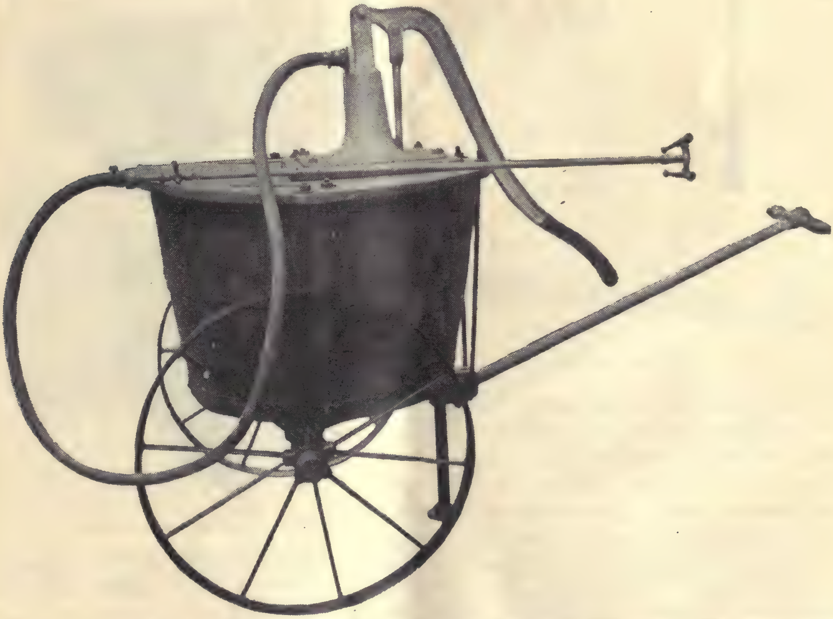

FIG. 27.—Twenty-five gallon spray tank mounted on wheels. Serviceable for greenhouse and field work.

the proper manner of application. Disregard of these factors will result in waste of material, possibly injury to the plants, and questionable results. To get the maximum results the spray material should be directed to all parts of the plant by simple wrist movements from side to side. Direct the spray up under the foliage as well as down upon the upper surfaces. An angled nozzle is very serviceable for such work. If one application is insufficient repeat at intervals of a few days. Do not wait until serious damage has been wrought before resorting to spraying. Give careful attention to the selection of the insecticide to be employed and consult text and Table 1 for specific information.

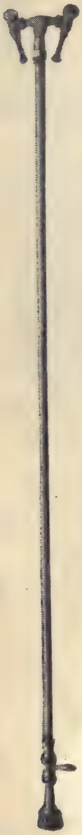

Fig. 28.—Spray rod made from brass rod, stop cock, reducer, angle connection, and double nozzle.

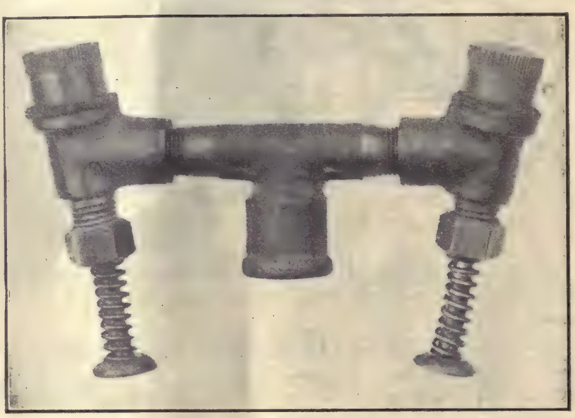

Fig. 29.—Cluster of two Vermorel (eddy-chamber type) nozzles equipped with degorger. (Quaintance and Siegler.)

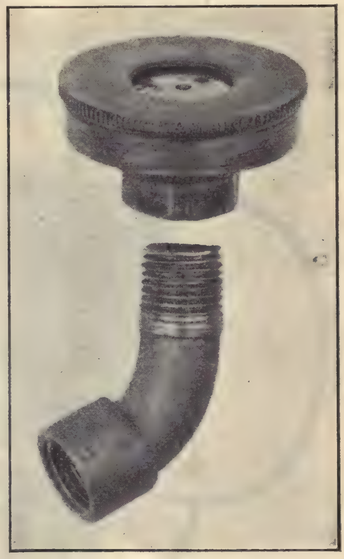

Fig. 30.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook. (Quaintance and Siegler.)

FUMIGATION.

Fumigation, in general, is valuable for killing insects only when the plants or substances treated are in an inclosed space, the object being to fill with poisonous gases the entire atmosphere in which the insects breathe. Greenhouses are admirably suited to such an operation. Tobacco extracts in the liquid form, or commercially prepared papers impregnated with tobacco. and hydrocyanic-acid gas constitute the substances more commonly used for greenhouse fumigation.

TOBACCO FUMIGATION.

Tobacco fumigation is employed by florists for the control of aphids, thrips, and white flies, when it is not convenient to use hydrocyanic-acid gas. Tobacco stems have been used extensively in the past but have now been discarded because of the difficulty surrounding their use. At present the burning of standard tobacco papers or especially prepared dusts impregnated with a definite amount of nicotine, or the painting of one or more steam pipes with the liquid extract, is a very convenient and efficient method of producing a smudge. Directions are usually given on the labels of the containers in which these materials are purchased. The active ingredients of the papers or dusts deteriorate with age, hence it is better to procure papers or dusts several times during the year than to rely upon one large consignment.

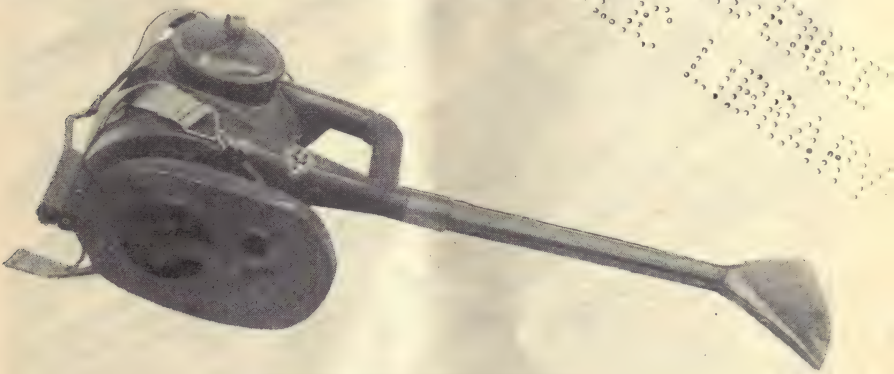

Fig. 31.—Hand duster, fan type.

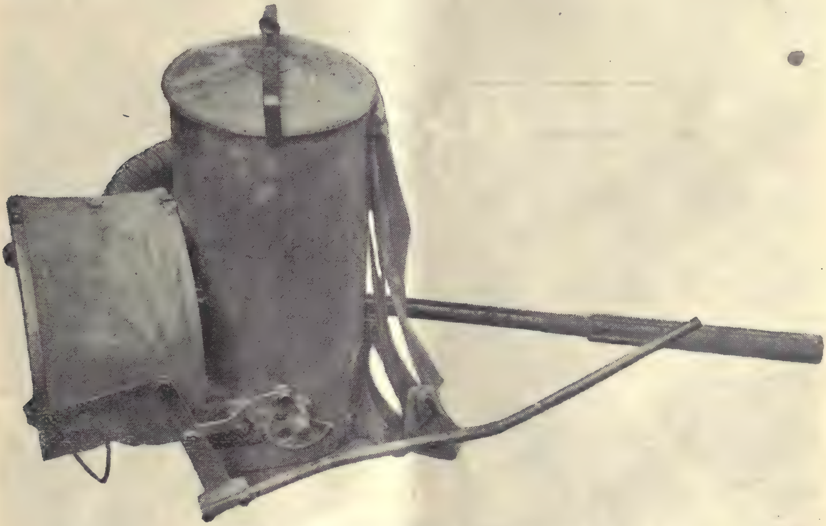

Fig. 32.—Hand duster, bellows type.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas is by far the most efficient and cheapest method of controlling thrips, aphids, white flies, and several scale insects on plants grown under glass. (Fig. 33.) It has not been generally adopted because of its deadly poisonous nature, as well as its disastrous effect on the tender plants if not properly used. The

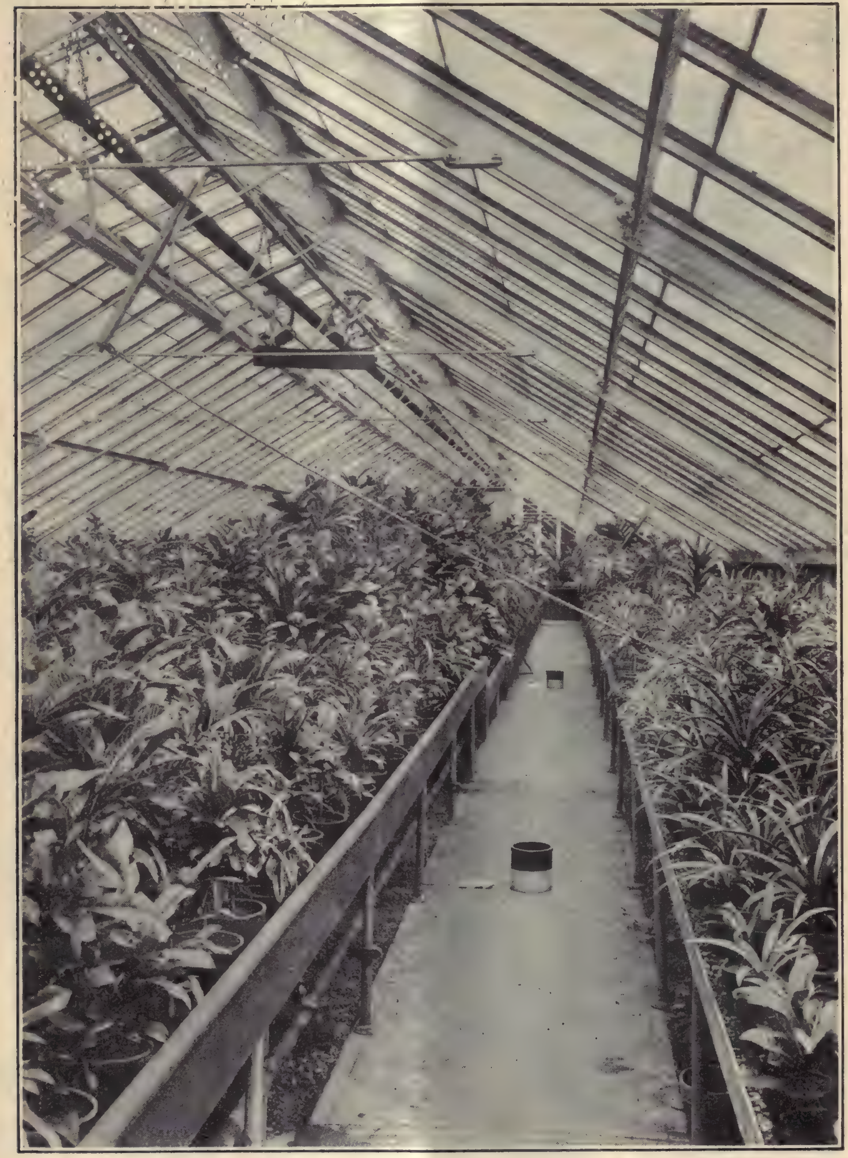

FIG. 33.—Greenhouse prepared for hydrocyanic-acid gas fumigation. The top ventilators are arranged so they may be opened from the outside and the generators and cyanid are placed. (Sasscer and Borden.)

prevailing impression, moreover, is that fumigation with this gas is a cumbersome procedure and requires particular skill on the part of the operators. Fortunately, chrysanthemums are not so susceptible to the effects of this gas as more tender plants and when fumigated under proper conditions will tolerate as high as 1 ounce of sodium cyanid per 1,000 cubic feet of space, with one hour exposure, without any injury. In competent hands when used at this strength most of the pests enumerated in this bulletin can be effectively controlled by it. Although chrysanthemums can stand as much as 1 ounce per 1,000 cubic feet of space, such a strength need not necessarily be employed in each case.

Specific information on the exact hydrocyanic-acid gas dosage required for the more important insect enemies of chrysanthemums is given in Table 1.

TABULATED SUMMARY OF METHODS.

TABLE 1.—*General outline for control of insects affecting chrysanthemums.*

Insects and insecticides.	Dosage.	Number of applications.[1]	Intervals between applications (in days).
Aphids:			
Hydrocyanic-acid gas fumigation.	½-ounce sodium cyanid per 1,000 cubic feet—1 hour.	2	10
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	3	8
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	8
Chrysanthemum midge:			
Hydrocyanic-acid gas fumigation.	⅛ to ¼ ounce sodium cyanid per 1,000 cubic feet—1 hour.	30 to 40	Nightly.
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	30 to 40	Nightly.
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	10 to 15	2 to 3
Cutworms:			
Poisoned bait	See formula (p. 25)	3	3 to 4
Lead arsenate spray	⅔-ounce powder per gallon	2 to 3	10
Leaf-tyers and leaf-feeding insects:			
Hydrocyanic-acid gas fumigation for adults.	1 ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	8 to 10
Lead arsenate spray	⅔ to 1 ounce powder per gallon	2	10
Red spider:			
Water syringing	30 to 50 pounds pressure		3 to 4
Soap solution spray	1 pound soap to 4 gallons water		7
Scale insects:			
Hydrocyanic-acid gas fumigation.	¾ to 1 ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	7 to 14
Soap solution spray	1 pound soap to 4 gallons water	3	7 to 10
Slugs, sowbugs, and millipeds:			
Poisoned bait	See formula (p. 25)	2	3 to 4
Thrips:			
Hydrocyanic-acid gas fumigation.	½ ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	5 to 7
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	3	5 to 7
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	8
Tobacco dust	Undiluted; or equal parts tobacco dust and sulphur (or lime).	3	8
White fly:			
Hydrocyanic-acid gas fumigation.	½ ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	10 to 14
Miscellaneous sucking insects:			
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	7 to 10

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[1] The number of applications required in a given case will necessarily be determined by the degree of infestation and the control secured by the treatments.

[2] It is assumed that tobacco papers or dusts will be used within the period specified on the containers in which purchased; also that the user will be guided by the other directions furnished by the manufacturers.

TABLE 2.—*Equivalent weights and measures.*

Liquid measure:	
16 ounces	1 pint.
2 pints	1 quart.
4 quarts	1 gallon.
29.57 (or 30) cubic centimeters	1 ounce.
1 teaspoon	4 cubic centimeters.
2 teaspoons	1 dessert spoon.
2 dessert spoons	1 tablespoon.
Dry weights:	
28.4 grams	1 ounce.
16 ounces	1 pound.

Fumigation of greenhouses with hydrocyanic-acid gas should not be undertaken in daylight under any circumstances, nor should it be done when the temperature of the house is below 55° F., or, in most instances, above 75° F., or when the wind is high, or on hot, humid nights when the extreme differences in temperature may prove disastrous to the plants. The exposure should not exceed 1 hour. after which the house should be thoroughly aired by raising the ventilators from the outside for a period of from 10 to 30 minutes, depending on the weather. Never enter a greenhouse charged with the gas until it has been thoroughly aired. If it becomes necessary to enter the greenhouse soon after ventilation, in order to determine the temperature, the person entering should not remain longer than is necessary. *One person should not attempt to fumigate a large greenhouse alone.*

Information on the fumigation of greenhouses with hydrocyanic-acid gas may be obtained by consulting Farmers' Bulletin 880, entitled "Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-Acid Gas," which may be had on application to the Division of Publications, United States Department of Agriculture.

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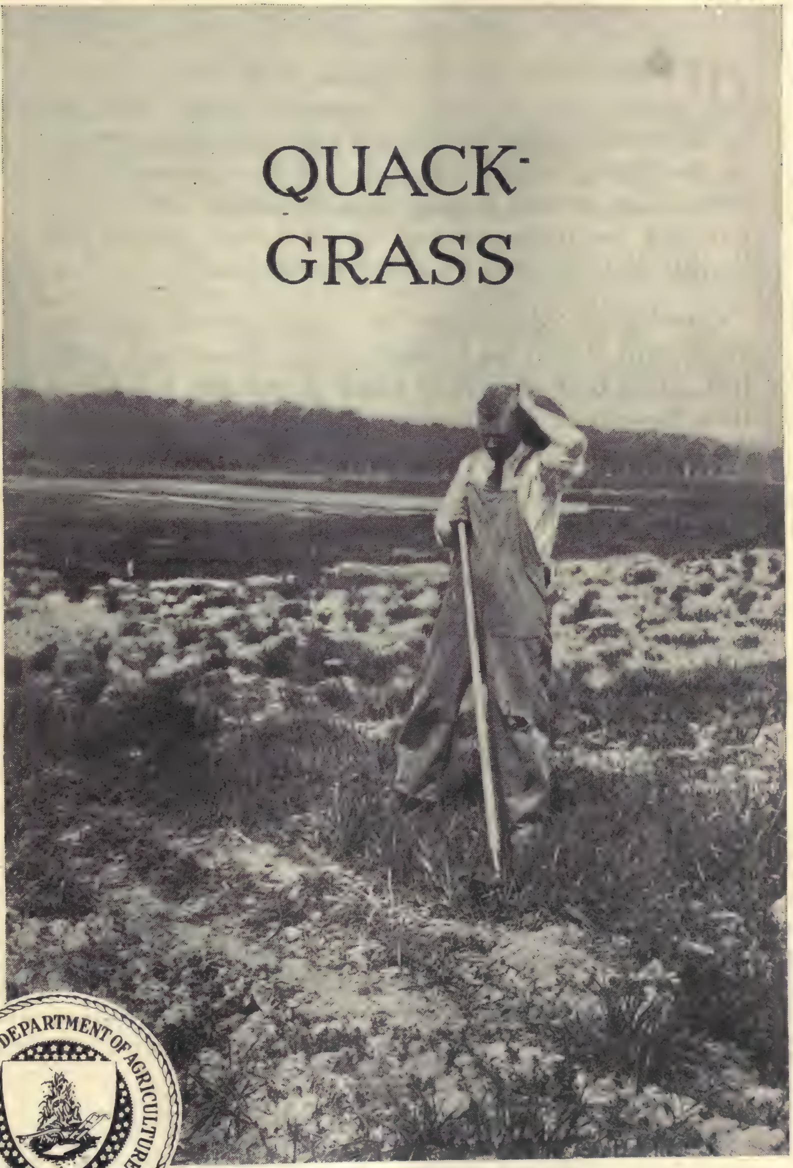
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1307

QUACK-GRASS



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QUACKGRASS or witchgrass is a creeping perennial grass, related to common wheat, and one of the most widely distributed and destructive weeds in the North Temperate Zone. It is often confused with other grasses having similar names and habits, but can be distinguished by the seed heads, the leaves, and the long, running rootstocks.

Quackgrass can rarely be exterminated on large areas, but it can be brought under reasonable control. The best plan is to allow it to form a sod and then plow it in midsummer during dry hot weather. Attacking the weed in wet weather or in the spring when the rootstocks are growing vigorously is almost a waste of time. After plowing, the field should be harrowed frequently until winter and the following year planted with a cultivated crop. A smother crop may follow the cultivated crop. On small areas quackgrass can be eradicated by hand digging, smothering with tar paper, spraying with chemicals, or by other means.

Quackgrass makes good hay, pasturage, silage, and lawns and often can be utilized more economically than it can be destroyed.

QUACKGRASS.

By L. W. KEPHART, *Assistant Agronomist, Office of Forage-Crop Investigations, Bureau of Plant Industry.*

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QUACKGRASS, or witchgrass (also termed "couch-grass" and "wire-grass," and having various other names), is a vigorous creeping perennial plant related to common wheat and widely distributed in cool, moist climates as a weed in cultivated ground. With the possible exception of the Canada thistle, quackgrass is the most notorious of all weeds and probably causes a greater monetary loss than any other single species of plant. Thousands of acres of the richest soils in the northern and eastern United States are so overrun with quackgrass as to be scarcely worth cultivating, while in several districts along the northern boundary entire farms have virtually been abandoned because the weed can not be controlled economically.

The weedy character of quackgrass is due to its remarkable system of creeping underground stems, or rootstocks, which spread through the soil in all directions, sprouting vigorously at the joints and resisting all but the most persistent efforts at extermination. Once well established in the field the weed is almost impossible to destroy, and it becomes more or less a permanent encumbrance on the land. Quackgrass is not entirely worthless, since it furnishes an acceptable quality of forage. The bad habits of the plant, however, outweigh its virtues.

DISTRIBUTION AND HISTORY.

In America quackgrass occurs most abundantly in the region north of the Ohio and east of the Missouri River. (Fig. 1.)[1] Within that area the weed is found in nearly every county, being in some localities the predominating plant. Quackgrass has been found by botanists in every State north of Florida and Arizona, but it rarely causes trouble as a weed south of the latitude of Washington and St. Louis. It occurs northward to the limits of cultivation, being common near Sitka, Alaska. During recent years quackgrass has been invading some of the valley lands and irrigated soils in the Pacific Northwest and in the region of San Francisco Bay, where it gives promise of being as troublesome as in the East. Quackgrass seldom thrives at altitudes greater than 2,000 feet, nor is it common in the semiarid regions of the Great Plains. In general, the distribution of quackgrass corresponds very closely to the regions where timothy and red clover are grown.

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[1] This map is based upon records in the Office of Forage-Crop Investigations, Bureau of Plant Industry, and sketch maps kindly furnished by officials of the following State agricultural experiment stations: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, Kentucky, Indiana, Michigan, Wisconsin, Minnesota, North Dakota, Iowa, Missouri, Colorado, Wyoming, Idaho, California, Oregon, and Washington.

Quackgrass is probably a native of Europe, although its history in America is obscure. Some of the earliest explorers in New England reported the finding of fields of "wild wheat" on the shores of the St. Lawrence River and in the White Mountains. The grass which they observed, however, was probably sea lyme-grass. The first authentic record of quackgrass is that of the Rev. Jared Eliot, of Connecticut, a friend of Benjamin Franklin and one of the first reliable writers on American agriculture. Writing in 1751 he states that "Tillage will entirely destroy and extirpate all grasses and weeds; yea, even that stubborn grass called bluegrass (Dutch, wire, or couch grass) which is so hurtful to corn." In 1813 the grass was definitely identified by the botanist Muhlenberg as occurring in New Jersey and New England.

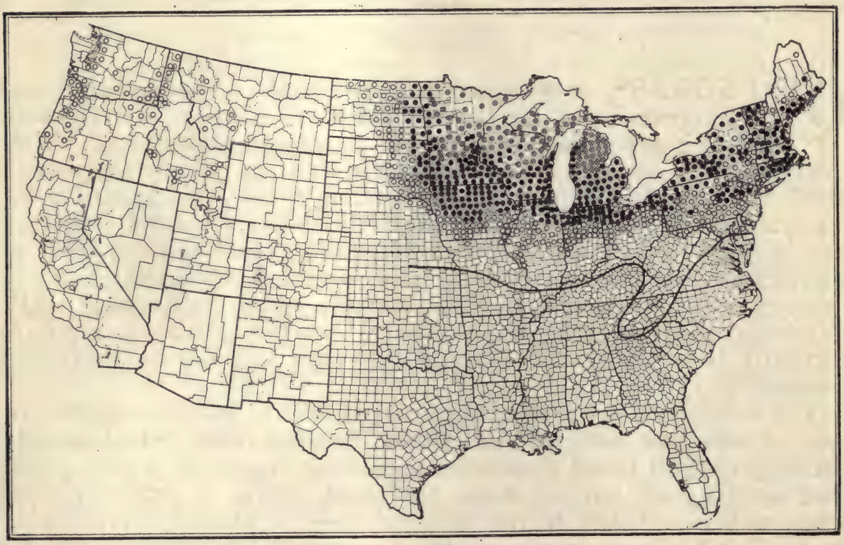

FIG. 1.—Outline map of the United States, showing the regions in which quackgrass is a troublesome weed. The dots show heavy infestation, the circles local infestation, and the crossed circles counties where the infestation is heavy but where agriculture is not highly developed. The solid line represents approximately the southern limit of quackgrass as a weed.

Quackgrass first attracted serious attention about 1837, when it was noticed in gardens in the vicinity of Philadelphia. During the decade 1840–1850 the grass became generally distributed throughout the region east of the Allegheny Mountains, whence it was gradually carried westward by the emigrant settlers. By

1859 the weed had reached Kent County, Mich., and it was just entering Iowa and Wisconsin in 1875. Minnesota was reached about 1890, but the spread of the grass through the Dakotas and other Western States is of comparatively recent date. At the present time the scene of the most active spread of quackgrass is in the prairie Provinces of western Canada.

In the Old World quackgrass has been a notorious pest as far back as there is definite record. In Lyte's translation of Dodoens, written in 1578, there is found the quaint but significant passage that "Couche grass is a naughty and hurtful weed to corne" (grain). Subsequently, nearly every writer on European agriculture has paid his respects to couch-grass in no uncertain terms, and it remains to-day one of the two or three most troublesome weeds in Europe.

Quackgrass occurs in all the countries of western Europe, and in Russia south to the Caspian Sea. In Siberia a river and a town are said to have been named for the grass, although the plant is not known to be common in other parts of Asia. A form of quackgrass occurs in Algeria and Tunis, but not elsewhere in Africa. In the Southern Hemisphere quackgrass is found occasionally in Argentina, and it is a weed of some importance in parts of Australia.

HOW TO RECOGNIZE QUACKGRASS.

One of the principal reasons for the wide distribution of quackgrass is the fact that it does not look like a weed. There are no bright, showy flowers, coarse, ugly leaves, or other features by which weeds are usually distinguished. To the casual observer the plant is simply a grass, and thus it works its way into the fields, becoming thoroughly established before it is recognized. It is most important, therefore, that the farmer should be able to identify quackgrass on sight.

In general appearance quackgrass resembles a thin-headed variety of wheat. The plant is, in fact, closely related to wheat, and as there are not many wild grasses which resemble that cereal, the occurrence of a wheatlike grass in the field should be regarded with suspicion. The grasses which might be confused most commonly with quackgrass on this account are western wheat-grass,[2] slender wheat-grass,[3] and wild rye[4] in the Prairie and Rocky Mountain States and Italian rye-grass[5] and perennial rye-grass[6] in the Eastern States. None of these grasses is hard to destroy.

Positive identification of quackgrass can be secured by examining the seed heads, the leaves, and the rootstocks.

SEED HEADS.

The seed head of quackgrass is a long, slender spike, about as long and half as wide as a head of wheat and with the seeds arranged flatwise to the stem rather than edgewise, as they are in the rye-grasses. (Fig. 2.) The heads may or may not bear short beards, and these, if present, break off at maturity. The seeds shatter easily when ripe, but usually remain inclosed in the hull, like small grains of oats.

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[2] *Agropyron smithii.*

[3] *Agropyron tenerum.*

[4] *Elymus* spp.

[5] *Lolium multiflorum.*

[6] *Lolium perenne.*

LEAVES.

The young leaf blade of quackgrass is likely to bear at the base, at the point where it joins the stem, a pair of small yellow claws, or horns, which project from the opposite edges of the leaf blade and nearly encircle the stem. (Fig. 3.) These claws are very characteristic of quackgrass and are not prominent in any other common

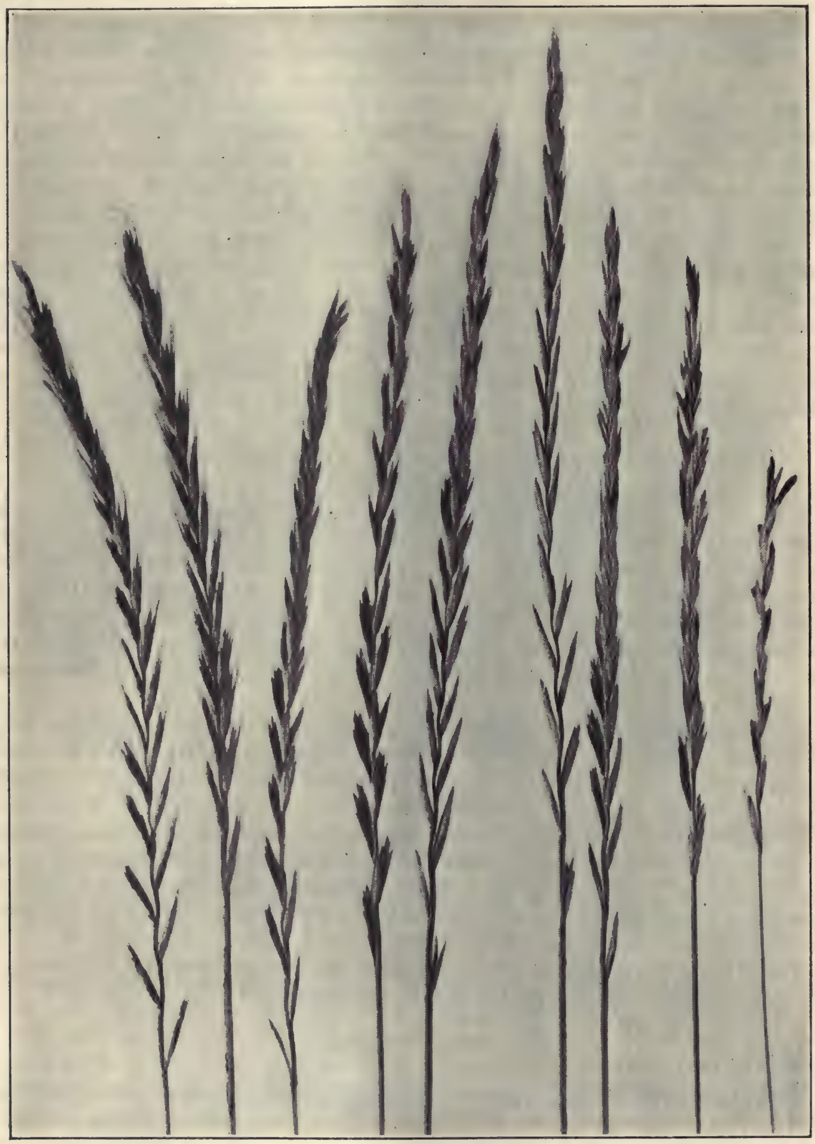

FIG. 2.—The seed heads of quackgrass are not unlike slender heads of wheat. Note that the clusters of seeds are arranged flatwise to the stem rather than edgewise. Also note the black grains of ergot on the head at the right and the rusted condition of the second stem from the left.

grasses except barley, wheat, and a few of the rye-grasses. A ragged membranous fringe, called the ligule, connects the claws at their bases. In many grasses the ligule is smooth or is replaced by hairs. The leaf blade itself is about the size and shape of a leaf blade of timothy, but is somewhat rougher on the edges and upper side and is more ascending, so that a patch of quackgrass has a distinctly bristly appearance. As in the case of rye, the quackgrass leaf often bears a curious slight constriction near the tip, as if a cord had been tied around the leaf and sharply pulled. (Fig. 4.) The portion of the leaf which incloses the stem has a tendency to be hairy when young and may be either split lengthwise or formed in a solid tube. The leaf blade is rolled, not folded, in the bud.

The color of quackgrass leaves varies. In the Western and Southern States the plants are often covered with a whitish bloom, which gives the leaves a bluish aspect. In the Eastern States the leaves are usually a rich dark green, readily distinguishable from the paler greens of timothy and wheat.

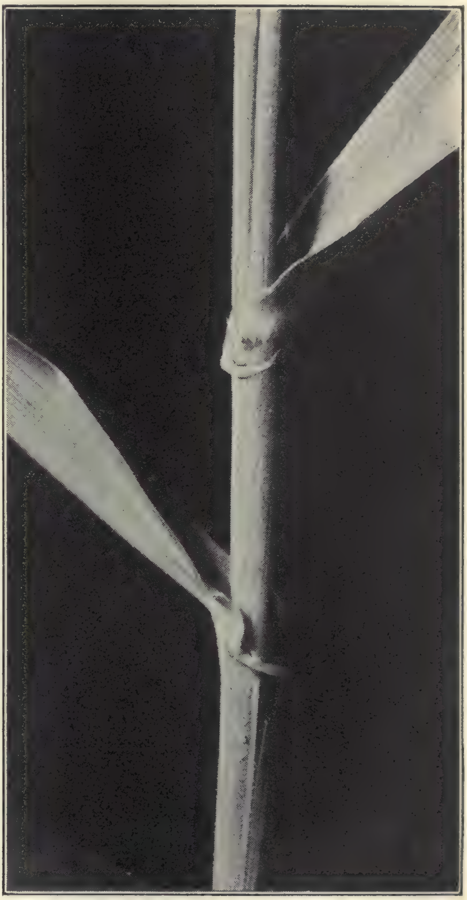
Fig. 3.—The two long curved horns or claws at the base of the young quackgrass leaf blade are an aid in identification. (Magnified 4 times.)

ROOTSTOCKS.

By far the most important characteristic of quackgrass is the elaborate system of creeping underground stems or rootstocks, commonly miscalled "roots." (Fig. 5.) Very few grasses common in the Northern States are equipped with such extensive underground organs, and the finding of them beneath a stand of grass constitutes an almost positive clue to the nature of the species. In the Eastern and Central States the only other important rootstock grasses are the Kentucky and Canada bluegrasses,[7] redtop,[8] and nimble Will.[9] In the West and Northwest brome-grass,[10] bluejoint,[11] and western wheat-grass and in the South Johnson grass[12] and Bermuda grass[13] possess rootstocks. In none of these except western wheat-grass does the seed head at all resemble that of quackgrass.

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[7] *Poa pratensis* and *P. compressa.*

[8] *Agrostis palustris.*

[9] *Muhlenbergia schreberi.*

[10] *Bromus inermis.*

[11] *Calamagrostis canadensis.*

[12] *Andropogon halepensis.*

The quackgrass rootstocks are long, slender, cordlike, yellowish white structures, about one-eighth of an inch in diameter, smooth, bare, and hollow except at the joints, where they are solid and closely covered with scaly rudimentary leaves. Branches are produced freely by the rootstocks, one at nearly every joint, and they in turn may become branched or push to the surface to form leafy shoots. If the rootstocks are broken, branches may arise from any joint along their length. Ordinarily, most of the branches form near the tips. When a rootstock strikes an obstruction it often breaks up into a snarl of twisted branches. If not obstructed it may grow straight through the soil for a foot or more without branching. A collection of rootstocks usually is a tough, tangled mass of stems very difficult to separate. When fresh, the root-stocks are firm, juicy, and tough, except at the joints, where they break with a clean fracture. As they dry, the rootstocks become brittle and are easily broken. The tip of each rootstock is armed with a sharp, hard point, which can penetrate the hardest soil or even a piece of soft wood or a potato.

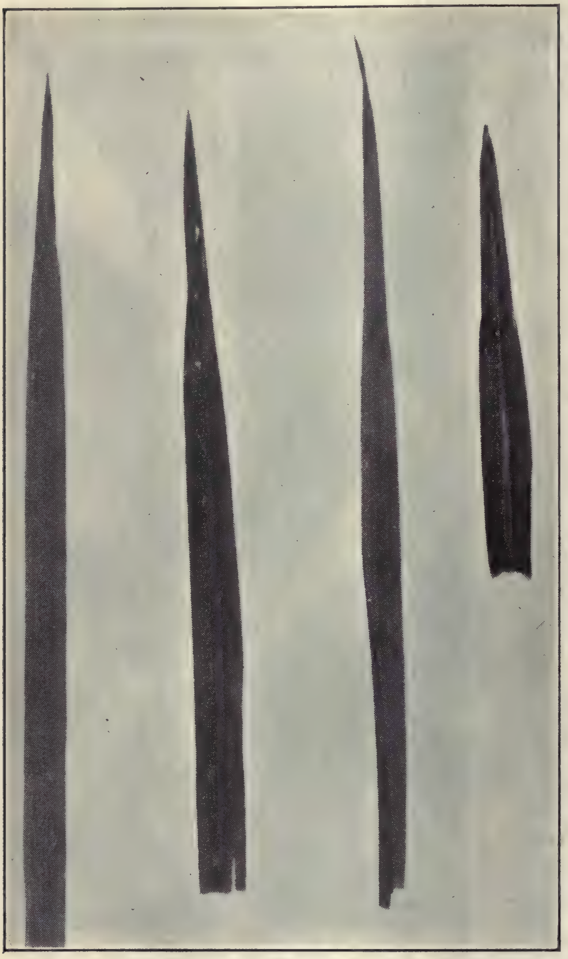

FIG. 4.—Quackgrass leaves; often characterized by a pinched appearance just below the tip.

The rootstocks have little to do with the absorption of food material and moisture from the soil, but serve as a means of spreading and as storehouses of food material. The true roots of quackgrass are mere fibers arising from the joints at the bases of the stems and on the rootstocks.

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[13] *Cynodon dactylon.*

COMMON NAMES OF QUACKGRASS.

The spread of quackgrass has been greatly aided by the lack of any single commonly accepted name and by the fact that the names that have been applied have also been used indiscriminately for almost any troublesome grass with running roots. The confusion of names has made it difficult to focus attention on the plant and has hindered concerted efforts at eradication. More than a hundred different names are known to have been in more or less general use, most of them variations of an old Anglo-Saxon word "cwice" or "quis,"

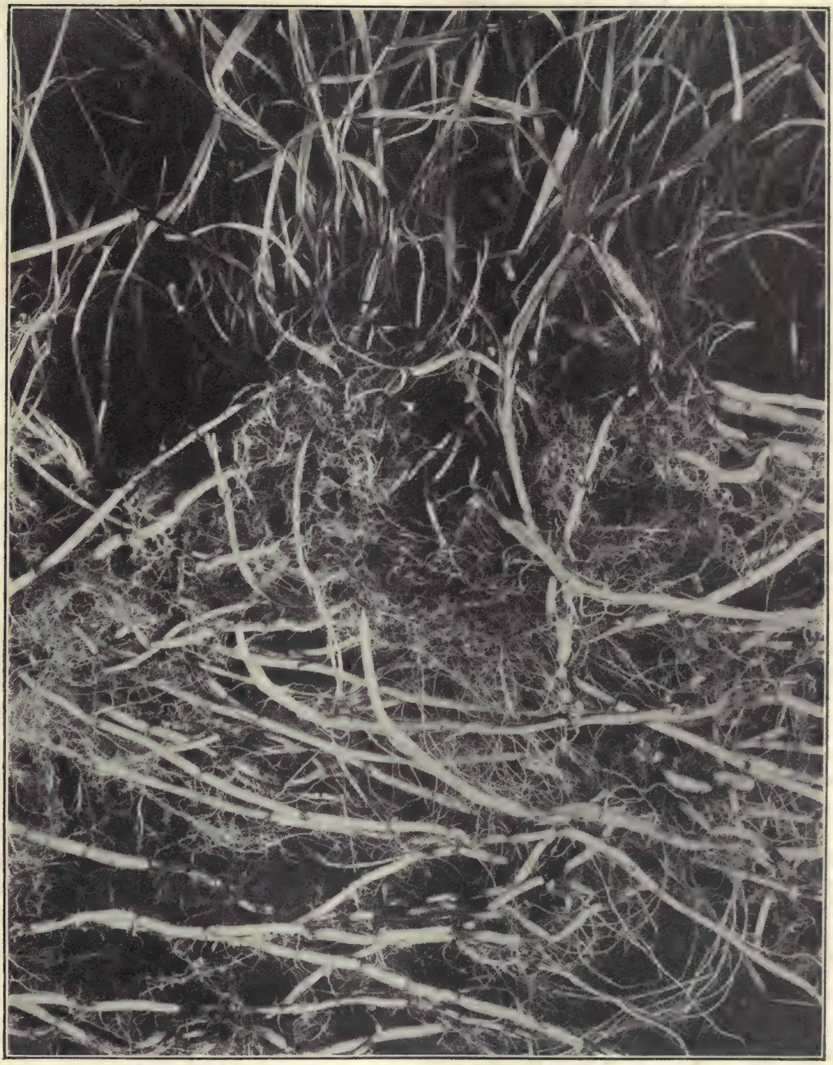

FIG. 5.—Typical quackgrass rootstocks. The weight of these creeping, sprouting underground stems often exceeds the weight of the stems and leaves above ground. The fibrous masses are the true roots. The green leaves may be seen above the mass of rootstocks.

meaning lively or vivacious. Typical derivations of this word appear in the common forms quitch, witch, quick, queck, quack, crack, crouch, couch, scutch, and Scotch. In addition, such names as dog, drag, Durfee's, Chandler's and English have had a local vogue.

At present quackgrass or some closely similar word is supplanting other terms in English and German speaking countries, although witchgrass is still popular in New England and couch-grass in some of the British possessions.

HOW QUACKGRASS IS INJURIOUS.

DAMAGE TO CROPS.

Quackgrass is an injurious weed only in plowed ground. In grasslands or roadsides and in waste places it is harmless except as a source of infestation and may even be beneficial for the herbage which it adds to meadows and pastures.

The chief sufferers from quackgrass are the small-grain crops, potatoes, beans, and farm gardens. Spring grain is more likely to be injured than winter grain, partly because it starts growth at the same time as quackgrass, and partly because it is often planted hurriedly in the spring on poorly prepared ground. The yield of spring oats and spring wheat is often reduced 40 to 50 per cent by quackgrass; barley suffers somewhat less, while rye and winter wheat are injured only occasionally. Fields of potatoes and beans are often veritable meadows of quackgrass in the fall, because the spreading habit of these crops makes it hard to keep the grass out of the rows late in the season. Corn and sugar beets are kept clean more easily than potatoes and are not likely to be injured severely by quackgrass provided the weed is kept down during the early part of the season. Quackgrass which grows up in cornfields late in the summer does not appear to reduce the yield materially either of grain or stover.

Quackgrass is often troublesome in orchards and vineyards; however, it does not seem to injure the trees and vines more than any other grass. Strawberry patches and asparagus beds are almost totally destroyed if quackgrass gets into them, as there is no way of killing the grass without killing the crop. Home gardens are among the worst sufferers from quackgrass. Large market gardens are not bothered excessively, owing to the more frequent and careful cultivations which they receive. Crops like buckwheat, hemp, millet, sweet clover, fodder corn, sorghum, vetch, and rape, which make a quick and heavy growth, are often not injured by quackgrass and may even be of service in eradicating the weed.

Besides reducing the yields of crops, quackgrass injures their quality. In some sections potatoes and other root crops are so frequently malformed by the sharp-pointed quackgrass rootstocks as to lower their grade on the market. Most of the larger field seeds, such as the grains and the larger grass seeds, are made almost unsalable if they contain quackgrass seeds in quantity. Notable examples of this are brome-grass and the wheat-grasses, the culture of which in the Western States has been seriously curtailed through fear of introducing quackgrass.

In common with many other grasses quackgrass is an active agent in spreading the red rust of wheat. It is also a frequent carrier of the poisonous fungus known as ergot and acts as a harbor during winter for the Hessian fly and other injurious insects.

LABOR COST.

Although the damage to crops is the most obvious injury caused by quackgrass, by far the most serious charge against the weed is the labor cost of keeping it under control. There is no way of estimating the amount of money spent each year in combating quackgrass, but the total without question is huge. Carefully kept accounts indicate that the cost of growing potatoes and beans is increased 15 to 40 per cent if quackgrass is present in the field. Similar figures probably apply to other cultivated crops. Although the labor factor is commonly overlooked, in reality it is the most convincing argument against allowing quackgrass to remain on a farm.

EFFECT ON LAND VALUES.

The presence of quackgrass in any quantity causes a sharp lowering in the market value of land. In neighborhoods where good land is worth $150 an acre a farm that is known to be infested with quackgrass often can not be sold for half that figure, while to many farmers quackgrass land is not considered a bargain at any price. In the opinion of experienced real-estate dealers the average depreciation of farm lands infested with quackgrass is not less than 25 per cent. If the weed is eradicated from such land the market value increases proportionately.

HABITS OF QUACKGRASS.

Quackgrass has few weaknesses that can be used to advantage in controlling it. Nevertheless, it is weaker at some periods than at others and knowledge of its habits may save much wasted time and energy.

LENGTH OF LIFE.

Quackgrass usually can not be made to disappear merely by leaving it alone. Although the individual rootstocks rarely live more than 15 months the formation of new rootstocks is such a continuous process that the plant can live indefinitely, even though no seeds are formed. Instances are not rare in which old grasslands that had not produced quackgrass seeds in more than 20 years gave rise to vigorous patches of the weed when the sod was plowed and the rootstocks broken up.

CLIMATE AND SOIL PREFERENCES.

Quackgrass makes its most luxurious growth in cool, moist climates and in rich soils. It grows but weakly in regions of long, hot summers, although it is able to withstand short periods of very dry weather better than most grasses. It thrives as far north as the limits of cultivation and practically never winterkills. Quackgrass is one of the first plants to start growth in the spring and one of the last to stay green in the fall. In the latitude of the Corn Belt it is earlier than any other grass except rye-grass and orchard grass, often having shoots 2 inches long before winter wheat resumes growth.

Quackgrass grows equally well in sandy, clayey, or gravelly soils, the extent of growth depending entirely upon the supply of water and plant food. It never occurs in swampy places or on muck soils or peat, and, conversely, seldom is troublesome on dry hillsides or other poor, hard soils devoid of organic matter. That the plant can withstand the presence of fairly large quantities of salt in the soil is shown by its occurrence on irrigated alkali ground in the West and its presence on the New England seacoast, where it grows right down to the water's edge. Experiments with chemical weed killers have shown that quackgrass survives an application of 20 tons or more of dry salt to the acre.

SEED HABITS.

Compared with other weeds quackgrass is a poor seeder. An average head contains about 25 viable seeds, and as a rule the seed heads are not so numerous as those in a good stand of wheat. In a test at Lansing, Mich., in 1916, the yield of quackgrass seed was found to be at the rate of about 18 bushels per acre. As the unhulled seeds are about the size of small oats this can not be considered a heavy production.

The production of seed depends somewhat upon the ease with which the plant spreads underground. When the rootstocks are free to develop rapidly, as in loose cultivated soil, the plant produces but little seed. When the rootstocks are closely crowded, as in grasslands, the seed heads are abundant. Similarly, more seed is produced on poor soil than on good soil, and more in dry seasons than in seasons of plentiful rainfall.

Like those of many other grasses the seeds of quackgrass are short lived and do not germinate well. When kept in open containers, such as grain bins, or sacks, most of the seeds lose their power to germinate in about four years. An occasional seed, however, retains its vitality for a much longer period. Hence, hay, grain, or other materials which are known to contain quackgrass seeds should be used with caution. When buried in the soil all quackgrass seeds within the upper 3 inches either germinate or die within two years. Those buried at a greater depth may persist for five years or more and grow when brought to the surface. Seeds which find their way into the silo usually have lost their power to germinate by the time the silage is removed. In manure the seeds retain their vitality for one to six months, depending upon the degree of heat and moisture in the pile. Very dry trashy manure which has not heated is dangerous to spread upon the land until it is more than a year old. In wet, heavy manure the seeds usually decompose in from six to eight weeks. The decay of the seeds can be hastened by turning the pile inside out about once a month, as the seeds in the center decay more rapidly than those on the outside.

Fresh seeds of quackgrass seldom show a germination of more than 50 per cent. Germination increases slightly with age and may reach 70 per cent by the time the seeds are 6 months old. One cause of the low germination is the presence on the seeds of a species of rust, which frequently attacks the plant very abundantly in the fall. Quackgrass is often so badly rusted, especially in the Northern Central States that only four or five viable seeds are to be found in each head.

In common with many weed seeds the seeds of quackgrass have the very dangerous characteristic of being able to germinate before they are fully ripe. Experiments conducted at the Minnesota Agricultural Experiment Station have shown that some of the quackgrass seeds are able to grow before the plant is fairly out of blossom. Germination of over 30 per cent was obtained from seeds gathered in the hard-dough stage, which occurs about two weeks before the seeds usually are considered ripe. Any crop that is harvested after July 1 in the southern part of the quackgrass region or after July 15 in the northern part, therefore, is likely to carry viable seeds of the weed.

While quackgrass seeds germinate most abundantly in early spring and in early fall, they may germinate at any time during the growing season, provided there is sufficient moisture in the soil. Plants which grow from seed in the fall usually produce seed the next year, but spring seedlings seldom bear seeds until the second summer.

ROOTSTOCK HABITS.

The first rootstocks do not appear on the quackgrass seedlings until the second or third month, or when the leaves are about 6 inches long. (Fig. 6.) Until that time quackgrass seedlings are hardly distinguishable from other grass seedlings and are easily destroyed by cultivation. When the rootstocks begin to form,

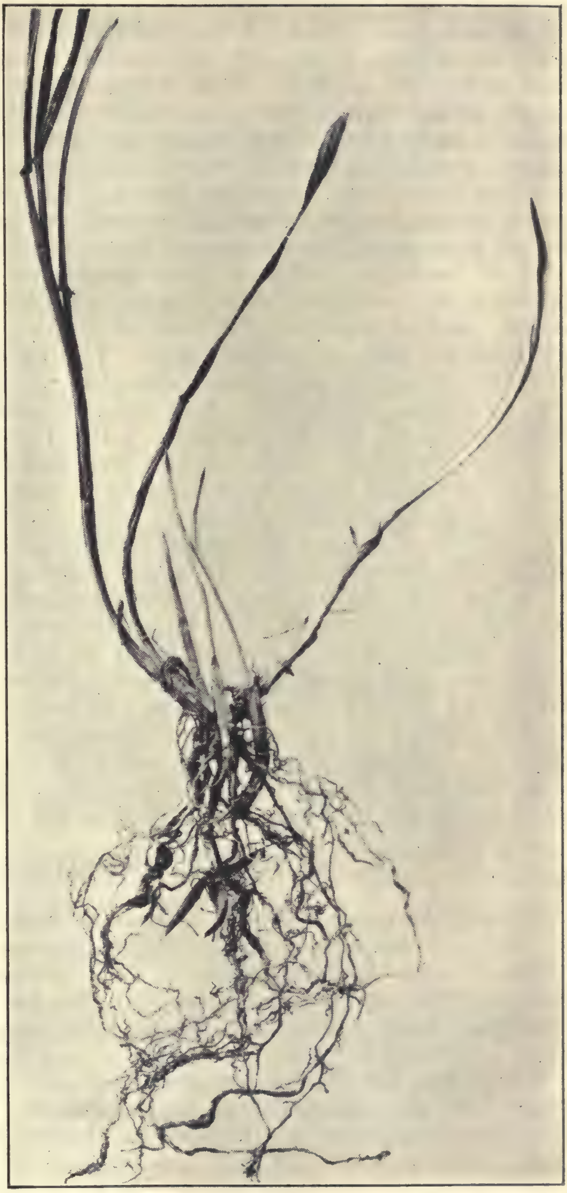

Fig. 6.—Quackgrass seedling 2 months old. The rootstocks are just beginning to develop and will not be large enough to be troublesome for another month.

however, they multiply rapidly and send up leafy shoots in profusion. A single quackgrass seedling in the course of a season gives rise to a patch of grass a foot or more in diameter. If not destroyed, such a patch widens in all directions at the rate of a foot or more a year. Most of the rootstocks are crowded in the upper 8 or 10 inches of the soil, and very few are found lower than a foot below the surface. The extent of the rootstock system of a single plant often exceeds the combined lengths of the aboveground stems. Individual plants which had been carefully dug up contained nearly 50 feet of "root" system having 40 or more seed-bearing stems and over 200 leaves. Not infrequently an entire patch of quackgrass measuring several feet in diameter is connected by the same set of rootstocks and is a single plant.

It is commonly believed that quackgrass has been widely distributed by means of dried pieces of rootstock carried in hay, straw, packing material, the roots of nursery material, in shipments of potatoes, and in similar ways. The danger from this type of infestation appears to depend somewhat on the rapidity with which the rootstocks are dried. The tops of some quackgrass kept in the greenhouse for four months without water died and the soil became very dry. When the soil was watered at the end of four months the grass began to grow as vigorously as ever. On the other hand, some bare fresh rootstocks which were exposed to the direct rays of the July sun for eight hours ceased to grow, even when artificially forced. It should be remembered, however, that in the field the rootstocks seldom become thoroughly dry, because of the rootlets and particles of soil which adhere to them.

By far the most important habit of quackgrass is its tendency to become root-bound when allowed to grow without molestation. In an old pasture or meadow the rootstocks usually are massed in a thin layer just beneath the surface, while in a cultivated field they are scattered through the soil to a depth of 8 or 10 inches. This fact is of the utmost importance in attempting to control this weed and is the weakest known point in the life history of the plant.

CONTROL PRINCIPLES.

There is no quick and easy method of controlling quackgrass, nor is there any one system that is satisfactory under all circumstances. Weather conditions, the kinds of crops grown, the supply of labor, and many other factors influence the choice of method, and these conditions vary widely in different localities and even on the same farm in different years.

Experience has shown, however, that certain phases of quackgrass control are quite constant and dependable, and these may be accepted as principles upon which the practice of control should be based.

WEATHER.

Quackgrass control depends more than anything else upon the character of the season. Fair weather is absolutely essential. Unless the season is reasonably dry and warm little headway can be made. Indeed, cultivation in wet weather is decidedly worse than useless and should be avoided under all circumstances, as the weed not only is not harmed but is actually encouraged to spread. Wet weather, of course, can not be foretold, and it often happens that rainy weather sets in after a campaign of eradication is well under way. Under such circumstances the only thing to do is to accept the situation philosophically, abandon the work temporarily, and await a more favorable season.

Excessively dry weather is sometimes as bad as wet weather. During long rainless periods the rootstocks dry out slowly and become dormant. The leaves cease to grow, and in that condition the plants are not injured by harrowing or cultivating.

In general, the ideal weather for killing quackgrass is hot days and cool nights with just enough moisture in the soil to keep the grass growing.

TIME OF YEAR.

The best time to attack quackgrass is in midsummer, just as the plants are forming seeds. Not only is there greater likelihood of favorable weather at that time, but the rootstocks are then at their point of lowest vitality. In the spring and fall the plants make heavy vegetative growth and store large quantities of reserve food material in the rootstocks. In midsummer vegetative growth is less active and the plants make a supreme effort to produce seed, the formation of new rootstocks practically ceasing and the old ones being drawn upon heavily for their reserve food material. In this weakened condition the rootstocks are less able to withstand attack and are much more easily killed than at other times of the year. In experiments at the Arlington Experiment Farm, near Washington, D. C., the weight of the rootstocks beneath an average stand of quackgrass was found to be at the rate of about 5,500 pounds per acre in April, 3,500 pounds in August, and 5,300 pounds in November, with a corresponding decrease in the content of starchy food material in midsummer. Other experiments showed that four cultivations begun in July were as effective in destroying quackgrass as six to eight cultivations begun in April. A further advantage of beginning in July is that the work is more likely to be done carefully in midsummer because other farm work is less pressing.

SIZE OF AREA.

On large tracts of land that are thoroughly infested quackgrass can rarely be completely exterminated. Even with the most careful culture a few rootstocks are certain to persist and these are enough to reinfest the area. The best that can ordinarily be expected is to bring the weed under reasonable control and by the use of a proper system keep it within such bounds that cultivated crops can be grown for four or five years at a time without undue interference. If one will reconcile himself to this fact and be content to control the weed rather than to eradicate it the problem will seem much less irksome.

On small areas quackgrass can and should be absolutely destroyed. Success on small areas depends entirely on the amount of time and effort one is willing to spend on the work.

PLOWED AND UNPLOWED LAND.

The tendency of quackgrass to become root-bound has already been noted. Because of this tendency quackgrass is far easier to control in grassland than in land that has been in cultivated crops.

The difference between plowed and unplowed land and the effect of different methods of plowing on quackgrass are illustrated in the accompanying diagrams.

Figure 7 represents the cross section of a field that has been plowed and cultivated in the ordinary manner. In this field the quackgrass rootstocks are scattered through the soil to the depth of the furrow slice. When such a field is plowed, as at the right of the diagram, the rootstocks are simply mixed more thoroughly into the soil and the field is in no better condition than before.

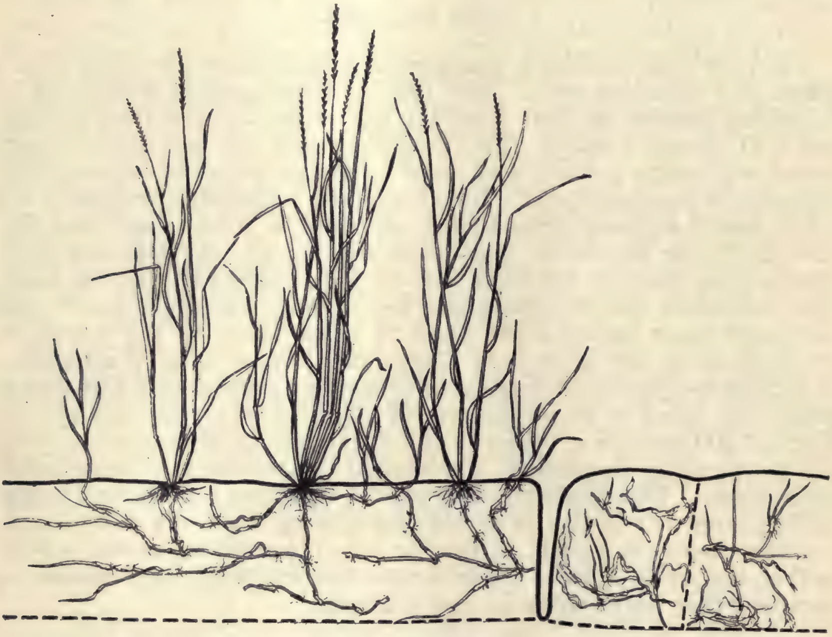

FIG. 7.—Diagram showing the effect of plowing a cultivated field 7 inches deep. The rootstocks are merely mixed more thoroughly into the soil.

Figure 8 represents a similar field that has been left in grass for a year or so. Here the rootstocks have become massed in a shallow layer just beneath the surface. The field, however, was plowed at the regular depth, thereby redistributing the rootstocks through the soil and putting the weed back in its original condition.

In Figure 9 is illustrated a system of controlling quackgrass that is effective and was formerly quite popular. In this system the field is in grass and two plows are used. The first plow goes only 4 inches deep and throws the mass of rootstocks into the bottom of a deep furrow alongside. The second plow follows immediately behind the first in the same furrow, plowing an additional 8 inches and throwing the soil on top of the rootstocks just turned. In this way the rootstocks are buried under 8 to 12 inches of soil and are nearly all killed at one operation. When this type of plowing is carefully followed the results are very satisfactory. The work requires skillful plowmen and special types of plows, however, and the soil must be deep and easily turned. Only rarely is it worth the extra trouble.

The best method of plowing quackgrass land is that shown in Figure 10. Here the field has been in grass, but instead of plowing deep the sod has been turned very shallow and the rootstocks left in a compact mass near the surface, where they can be readily stirred by the harrow and dried.

CULTIVATION.

Cultivation of a crop like corn or potatoes, in the manner in which that operation is usually performed, is almost entirely worthless as a means of destroying quackgrass. On the contrary, it is one of the most effective means of spreading the weed over a farm. Instead of harming the grass the teeth of the implement tear out the rootstocks, break them in pieces, and drag them down the row, setting up a new area of infestation wherever a piece is dropped. The cultivator and the harrow are among the most efficient distributors of quackgrass on the farm, and if carelessly handled may do more harm in a single hour than can be overcome in several years.

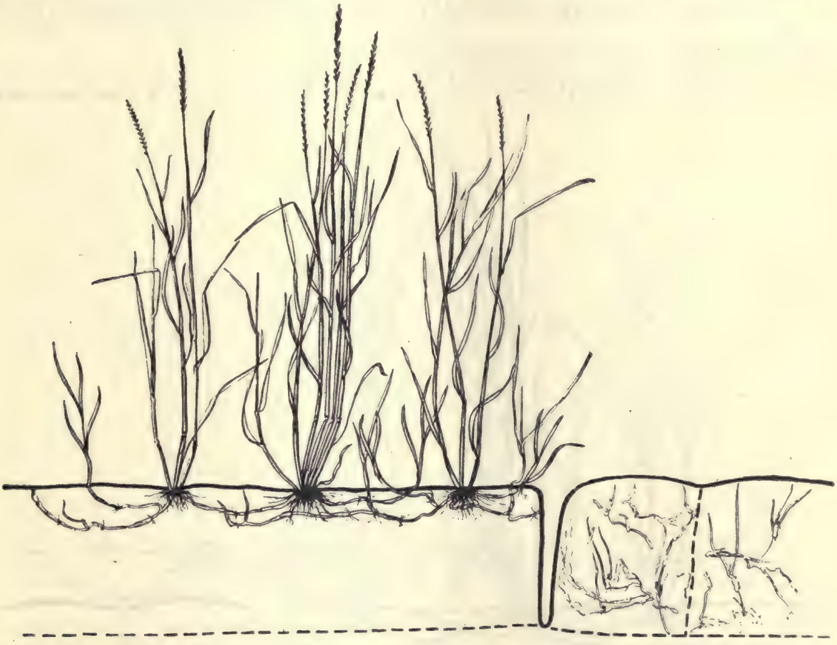

FIG. 8.—Diagram showing the effect of plowing a pastured field 7 inches deep. The rootstocks are remixed through the soil to the depth of the furrow slice.

To be effective against quackgrass, cultivation and harrowing must be thorough, frequent, and persistent. Half-way cultivation is worse than none. The weed thrives on an occasional stirring, and if it is to be destroyed must be cultivated so often that it does not have a chance to become rooted. There is scarcely a better way to make two blades of grass grow in place of one than to cultivate a patch of quackgrass at long intervals.

CONTROL PRACTICES.

A USEFUL ROTATION.

Based on the general principles already mentioned, the following system of cropping is suggested as a means of holding quackgrass in check on large areas. Such a system can seldom be followed exactly, but on most farms it can be modified to meet local conditions and will serve as a basis on which to work:

Seed the land to grass, pasturing closely or cutting for hay.

As soon as the grass is sod-bound, plow shallow in July immediately after haying.

Harrow until frost as often as new leaves appear.

In the spring plant a cultivated crop.

The following year, if the grass is still abundant, sow a thick smother crop.

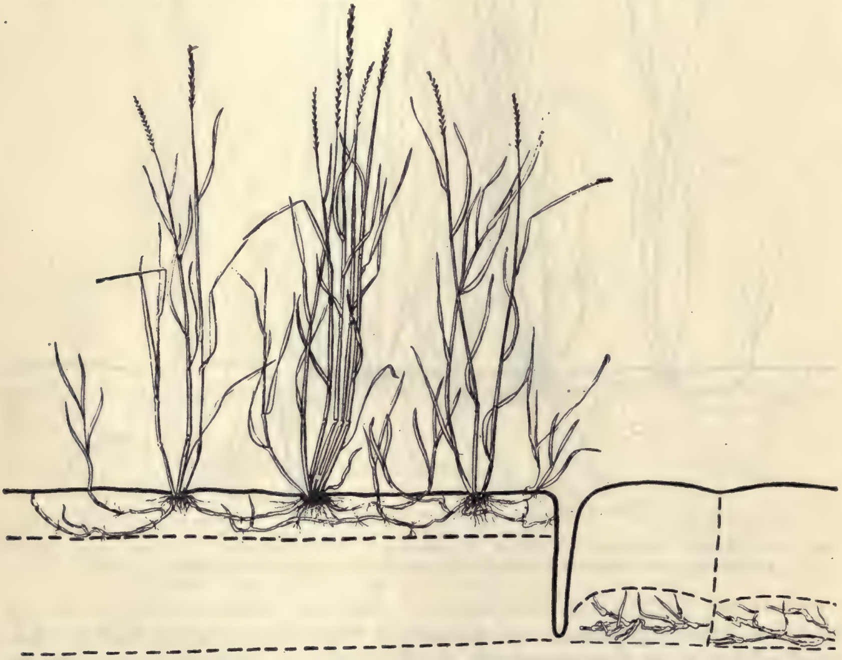

FIG. 9.—Diagram showing the effect of double plowing a pastured field and burying the rootstocks under 12 inches of soil. An effective method of destroying quackgrass, but expensive and laborious.

SEEDING TO GRASS.

The object of seeding to grass is to obtain a tight, thin sod with the rootstocks matted near the surface. If possible, the field should be used for pasture, as this makes the most compact sod. In heavy clay soil that is closely pastured, the grass will become densely sodded within a year or 18 months. In sandy soils from two to four years are required. Hayfields require about a year longer than pasture fields to become well root-bound. For grazing purposes horses and sheep are better than cattle, as they bite more closely and trample the ground more. When the infested land is being used for a garden, the garden often can be located elsewhere for a time and the space used for a poultry yard or converted into a temporary lawn.

PLOWING.

When the rootstocks have been brought near the surface, plow in midsummer at the time when the quackgrass normally would be in full bloom. This occurs in most parts of the northern United States between June 20 and July 10, although blossoming may be delayed if the season is dry. Plowing should be only as deep as is necessary to get under the lowest live rootstocks. In an old pasture 3 inches is sufficient; in a meadow from 3 to 6 inches. In cultivated land it sometimes is unnecessary to plow to a depth of more than 4 inches, as the old rootstocks at the lowest depths are often so exhausted that they are not dangerous. Turn the furrow flat and cover all the leaves completely, being particularly careful to plow out the back furrows.

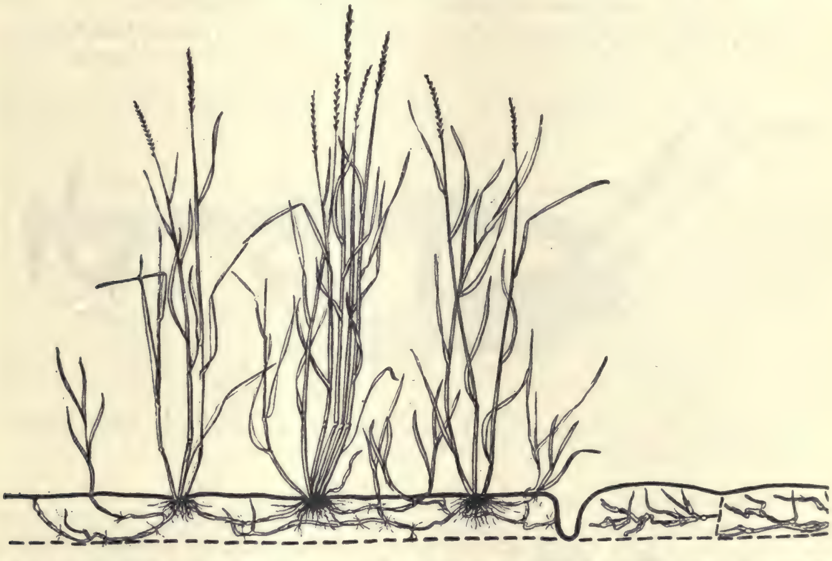

FIG. 10.—Diagram showing the effect of shallow plowing on a pastured field, the easiest way to destroy quackgrass. The rootstocks are all left within reach of the harrow.

Plowing to a depth of only 3 or 4 inches with the ordinary stubble plow found on most farms is somewhat difficult, although it can be done with a steady team. When large areas are to be plowed it usually pays to obtain a special sod plow designed to turn a thin flat furrow. The so-called prairie breaker (Fig. 11) is excellent for this purpose, although somewhat heavier than necessary. A type of plow known by some manufacturers as the Scotch bottom or clipper bottom also does good work and can be used for general plowing as well. Some so-called Scotch bottom plows, however, are especially designed to turn the furrows on edge, which, of course, is not the result desired in this case. If the sod is hard and tough a rolling colter, a fin colter, or the new combined colter and jointer helps to cut the rootstocks. When plowing a meadow which for any reason has not been mowed it will be necessary to attach a light chain or a No. 9 wire from the clevis to the handle near the end of the moldboard in order to turn the tops under the shallow furrow.

HARROWING.

After plowing let the field alone for a week or 10 days or until the grass has begun to send up new leaves. This helps to exhaust the rootstocks. When the new leaves have reached a length of about an inch harrow the field crosswise with a spring-tooth harrow, to tear the chunks of rootstocks apart and to shake off the soil. Repeat this operation as often as the quackgrass leaves become an inch long. In seasons of normal rainfall four or five harrowings before frost will be enough, although the number may run as high as eight or ten if the growing conditions are especially favorable.

The best all-round harrow for subduing quackgrass is the spring-tooth type, although there are a number of special quackgrass harrows that do excellent work. The disk harrow, either plain or cutaway, is a good tool, provided the work is well done. The disks cut the rootstocks into small pieces, however, instead of dragging them out as does the spring-tooth harrow, and these small pieces are likely to take root again if the field is not harrowed frequently. The spike-tooth harrow and the duck-foot types are useful in soils that are not loose or stony.

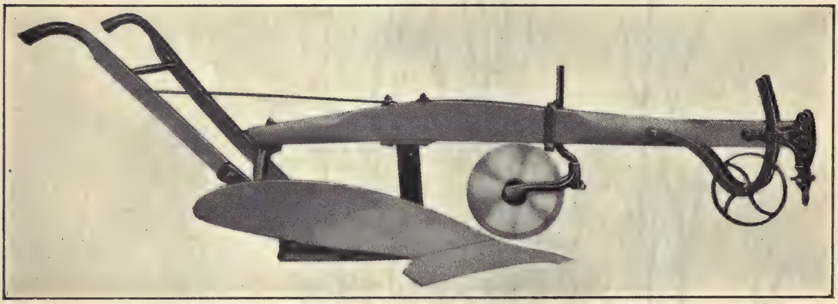

FIG. 11.—The prairie breaker, a plow with a long narrow moldboard especially designed for turning a shallow flat furrow, a very useful implement in fighting quackgrass The rolling colter aids in cutting the tough rootstocks.

Always choose a hot, dry day on which to harrow and try to stir and turn the rootstocks to aid in drying them. Often the dry rootstocks can be raked into piles with the harrow or a hayrake, after which they should be carted away and burned.

In the fall, if the rootstocks are not well loosened from the ground, plowing should be repeated. Allow the field to remain rough over winter, to expose the rootstocks to the frost. If there is danger of soil washing, sow a bushel of rye to the acre as a cover crop.

CULTIVATED CROPS.

In the spring, as soon as the weather permits, loosen the rootstocks from the soil with the harrow. Do not plow unless the ground is very hard or the grass firmly rooted. Lack of plowing will not injure most crops. Plant a cultivated crop that is easily kept clean, corn in checkrows usually being the most convenient. Sugar beets are also excellent, as they require close cultivation and can be kept clean in the rows. In some sections soy beans in rows for seed have proved very satisfactory. Potatoes, tomatoes, cannery peas, and bushy types of field beans are to be avoided, as it is practically impossible to keep the weed out of the rows of these crops during the latter part of the season. Tobacco is unsatisfactory, because it is too easily injured.

Of the many types the disk cultivator is one of the best for subduing quackgrass. If the ground is not stony the disks cut the grass off cleanly, do not clog, and are easily handled. The disks must be kept sharp, which is sometimes difficult in sandy soil. In gravelly and stony soils there is nothing better than the ordinary five-shovel or six-shovel corn cultivator, although the spike-tooth or harrow-tooth cultivator, where it can be used, tears out more of the grass. Cultivators of the scraping or knife-blade type, as well as duck-foot implements, are excellent when sharp but are quickly dulled, in which condition they tend to jump and slide over the weed and to push it ahead instead of cutting it.

SMOTHER CROPS.

A smother crop is any crop that makes a heavy, dense growth and kills the weeds by crowding and shading. In very rich soils the smother crop can sometimes be used in place of the cultivated crop the first year after the ground is plowed. Ordinarily, however, the smother crop must follow the cultivated crop, as otherwise it can not be depended upon to make a sufficiently heavy growth to kill quackgrass. Its purpose is to clean up the stray plants that escape the cultivator. Since a smother crop must make a dense growth to be of any service, it usually pays to fertilize this crop heavily with manure or commercial fertilizer.

Almost any crop that produces a rank growth can be used for smothering. Corn in thick rows for fodder is perhaps the most generally useful. It should be planted with a drill in rows 2 feet apart, using not less than 2 bushels of seed to the acre. If the corn makes a sufficient growth to smother the quackgrass it will not need cultivating after the first two weeks.

Buckwheat has quite a reputation as a destroyer of quackgrass. (Fig. 12.) The particular advantage of buckwheat is that it need not be planted until the end of June, thus allowing time for the cultivation of the ground during the spring. This fact is a disadvantage, however, if the cultivation is neglected. Buckwheat must be planted on well-prepared ground and should be seeded at the rate of at least 5 pecks to the acre.

In sections where it can be grown commercially, hemp is an excellent smother crop. In parts of Wisconsin it is said to destroy quackgrass and Canada thistle without the aid of a cultivated crop. Hemp is not an economical crop to grow unless there are local scutching facilities for preparing the fiber; however, it may be found useful anywhere on a small scale.

Rape, especially the Dwarf Essex variety, is a good smother crop if planted in thick rows on rich soil. It has been especially recommended for controlling quackgrass in parts of Canada. As the crop is usually grown in this country, however, it does not make a growth heavy enough to have much effect on the weed.

Spring barley, following a season of clean cultivation, has been used with very good results in some of the Western States. Barley is more leafy than the other small grains and is well able to hold its own against quackgrass.

Peas or vetch with oats which have been used with success in the cool portions of the more northern States, especially in the Pacific Northwest, are useful only on rich soils well supplied with moisture.

Golden millet, also known as German millet, has long been known as a good smother crop, but this reputation is scarcely deserved as far as quackgrass is concerned. It grows but little taller than quackgrass, and if the soil is sufficiently rich to make a large growth of millet the quackgrass is encouraged also.

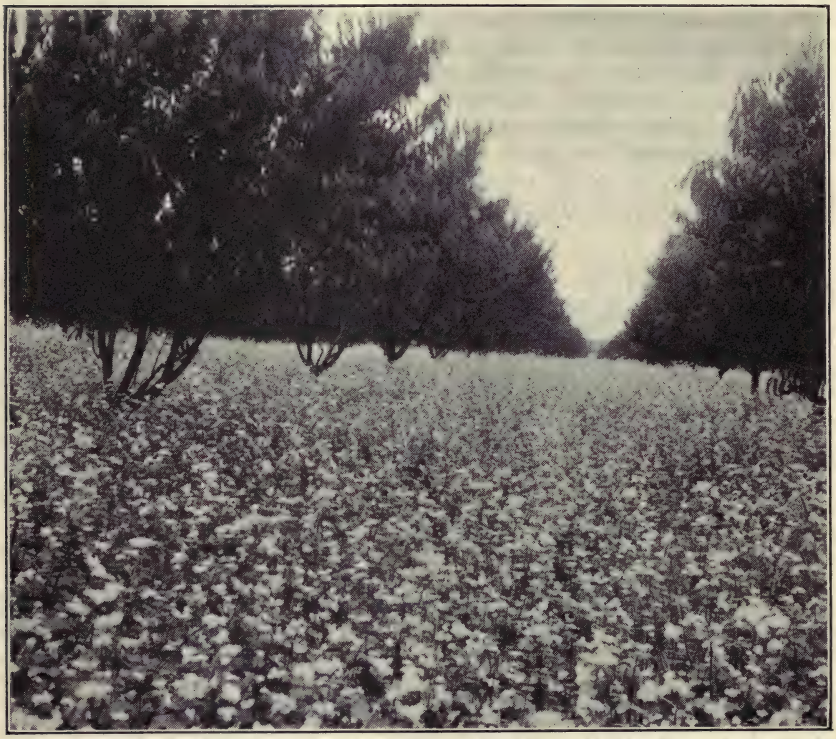

Fig. 12.—A thick, rapid-growing smother crop is very useful to follow a cultivated crop and clean up stray plants of quackgrass. Buckwheat is often used for this purpose.

Recently sunflowers have attracted attention as a smother crop for quackgrass and are reported to have been very satisfactory in northern Michigan and South Dakota. They must be planted thick and should be given a good application of fertilizer to start them rapidly.

In the region south of the latitude of Chicago, Red Amber sorghum is a good smother crop. It should be planted in 14-inch rows with a grain drill and allowed to mature for seed.

Sweet clover has sometimes been known to smother quackgrass and where it makes a rank growth may destroy the weed. The plants must be thick on the ground, however, and must attain a height of not less than 6 feet. Unless the soil is very rich the sweet clover and quackgrass are likely to grow excellently together, making a good forage combination, but not eradicating the weed pest.

MISCELLANEOUS METHODS OF CONTROL.

HAND DIGGING.

Usually the most convenient way to destroy a small area of quackgrass is to dig it out by hand. The work must be done thoroughly, however, for any small piece of rootstock left in the soil may renew the weed. Simply cutting off the leaves of the grass and digging out as many of the rootstocks as can be reached conveniently with a hoe is not enough. The entire area must be carefully dug over to the depth of the lowest rootstock and each piece removed by hand or by sifting. A convenient way is to throw all the soil into a pile outside the area, throwing it back again as the rootstocks are removed. The treated area should extend at least a foot beyond the borders of the quackgrass in order to get all the rootstocks. The best season for digging is from June 15 to July 15.

SMOTHERING WITH TAR PAPER AND OTHER MATERIALS.

A less laborious but slower method of destroying small patches is to cover them from May until September with tar paper, straw, manure, old tin roofing, boards, or any other material that will totally exclude the light. The tar paper should be of a heavy grade and laid so as to overlap about 3 inches, and the laps should be weighted with earth to make a tight joint and prevent the paper from blowing away. (Fig. 13.) Straw must be piled 3 feet thick and manure at least 1 foot to keep the grass from growing through. All coverings should extend 2 feet or more beyond the limits of the patch.

CHEMICAL WEED KILLERS.

The only way to destroy quackgrass with chemicals is to soak the ground with some powerful plant poison; hence the process is practicable only on a small scale. Likewise, there is no way to kill quackgrass with chemicals without killing all other vegetation. The method is chiefly useful for keeping the grass down around fences, foundation walls, yards, gutters, and other places where no vegetation is desired. Sometimes quackgrass can be prevented from spreading to uninfested areas by inclosing the patch with a narrow strip of ground soaked with a weed killer.

The most effective chemical for destroying quackgrass is sodium arsenite, used at the rate of 2 to 3 pounds in 10 gallons of water to each square rod. This prevents the growth of quackgrass and other weeds for about 18 months. Fuel oil or other low-grade oils at the rate of 300 gallons an acre are also useful. Common salt is not injurious to quackgrass even when used in large quantities. Among other chemicals which have been used against quackgrass without success are iron sulphate, copper sulphate, sulphuric acid, carbolic acid and other coal-tar derivatives, mercuric chlorid, potassium dichromate, and a variety of arsenicals, carbonates, sulphids, and hydroxids.

PASTURING WITH HOGS.

As hogs are very fond of fresh quackgrass rootstocks, they are often turned into a field that is being plowed. It is possible to reduce quackgrass greatly with hogs by withholding other feed and giving the animals plenty of water and shade. The hogs can not be expected to gain while on quackgrass pasture, but this loss may be offset by the destruction of the weed. Hogs which are strong rooters, such as Tamworths, are best, and their noses, of course, should not be ringed. Six hogs will remove a large percentage of rootstocks from an acre in one month. Sheep will also pick up many quackgrass rootstocks.

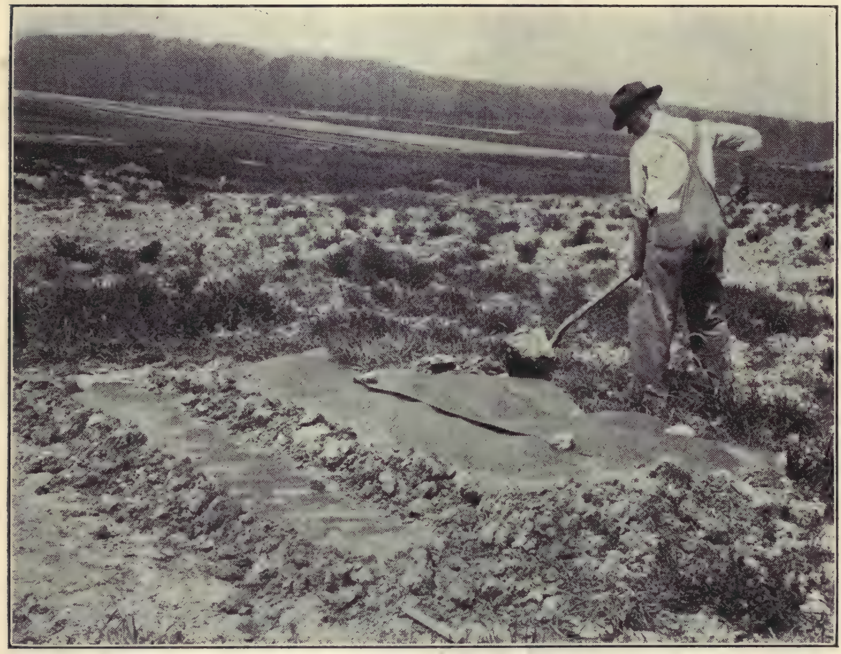

FIG. 13.—Small patches of quackgrass can be killed by covering them with tar paper for three or four months.

SPECIAL MACHINERY.

A number of special machines have been devised for killing quackgrass, most of them being designed to dig out the rootstocks and separate them from the soil, somewhat after the fashion of an elevator potato digger. Several of the machines have been satisfactory mechanically, but are too expensive for general use. As a rule, such machines do not destroy the weed completely, although they make it easier to kill the grass by cultivation and shading.

PRECAUTIONS NECESSARY TO KEEP QUACKGRASS OFF THE FARM.

Prevention is always better than cure. While it is not always possible to keep quackgrass from the farm there are certain precautions that should never be overlooked.

USE GOOD SEED.

Quackgrass is most commonly brought on the farm in grass and grain seed. Oats, barley, brome-grass, and slender wheat-grass are the most usual carriers of the weed, although wheat and rye, if not well cleaned, may bring it. In wheat and rye the quackgrass seed is likely to be hulled, in which condition it closely resembles the rye. European brome-grass seed has been an especially prominent carrier of quackgrass seed in the Northwestern States. American-grown seed, however, is not always free from the weed. The smaller field seeds, such as timothy and the clovers, if properly cleaned, rarely contain quackgrass seed.

BE CAREFUL ABOUT HAY AND STRAW.

Any hay or straw harvested after July 1 is likely to carry quackgrass seeds as well as pieces of the rootstocks picked up in raking. The rootstocks are not dangerous if thoroughly dried, but some at the bottom of the stack usually remain moist. Very frequently the appearance of quackgrass around an old straw pile is traceable to the thrashing machine, which brought in the weed seeds hidden in crevices under the shakers and in the tailings spout. Hay balers are also frequent offenders in this respect. Do not hesitate to clean these machines thoroughly with a broom before they are permitted to drive on the farm. Any local law on the subject should be enforced.

DO NOT SPREAD INFESTED MANURE ON GRASSLAND.

Manure that is thought to contain quackgrass seeds should be piled until well rotted or spread on land that is to be cultivated within three weeks. The young seedlings do not develop rootstocks until they are 4 or 5 weeks old, and can be destroyed as easily as other seedlings before that time. Infested manure should never be used for top-dressing pastures or meadows, as there is no way to kill the young seedlings without destroying the pasture or meadow. Quackgrass seeds usually get into manure through the bedding, although they may come from the hay or grain fed to horses, as the seeds are not always killed by the process of digestion.

DESTROY THE FIRST SMALL PATCHES.

When quackgrass first appears on a farm it should be totally exterminated, regardless of trouble or expense. Cost is no consideration in destroying a small patch of the weed. The area should be marked with stakes and the weed destroyed utterly. Repeated digging and removal of the rootstocks is satisfactory, but covering the patches with tar paper is more certain. The particular method is of little consequence; the object is to kill the weed before it can gather headway.

WATCH THE HARROW AND CULTIVATOR.

Careful cultivation is most important. If necessary to cultivate through a patch of quackgrass, lift the implement when crossing it, or at least clean the teeth thoroughly after passing. A few minutes spent at this point may mean the eventual saving of hours.

COLLECT AND BURN THE ROOTSTOCKS.

When piles of rootstocks have been collected in the field by the harrow or cultivator, cart them to some out-of-the-way place and burn them. The temptation is to dump them in the road or along the streams or fences. From such places they are easily carried to adjoining land and may cause much ill feeling in the neighborhood.

DO NOT LET QUACKGRASS GO TO SEED.

The wisdom of preventing quackgrass from going to seed by cutting it when in full bloom seems too obvious to need discussion. Unfortunately, the blooming period comes just when other farm work is very pressing and few farmers care to take the time to cut weeds. Because of the serious nature of quackgrass, it pays to cut it when necessary, even if other work must be neglected for a few hours. As quackgrass seeds can grow before they are fully ripe, the weed should be cut before the seeds are hard.

UTILIZATION OF QUACKGRASS.

Although quackgrass is known chiefly for its bad habits as a weed it is by no means entirely worthless. When cut early it makes hay equal to timothy and is perhaps a better hot-weather pasture plant than any other crop except sweet clover. In several other ways quackgrass has been found useful, and its utilization should not be despised or neglected simply because the plant is a weed.

It is not necessary, of course, that quackgrass be planted purposely or that it be used in any way that could possibly cause harm. Several cases are known where the grass has been introduced into new territory as a promising forage crop, with results disastrous to the neighborhood. Planting quackgrass, for forage purposes at least, is entirely unnecessary, as there are always other plants that answer the purpose quite as well and are much less difficult to control. Similarly, the practice of selling quackgrass hay should be strongly condemned, as the hay is almost certain to contain viable seeds.

Where quackgrass already occurs in abundance, however, and there is little possibility of it injuring other persons, there is no reason why it should not be used; indeed, there are many times when it would be more profitable to utilize the plant than to try to keep it under control. Consequently, before undertaking an expensive program of eradication, weigh carefully the value of the cultivated crop that might be raised, the cost of raising it, and the value of the quackgrass hay and pasturage.

USE AS HAY.

Most weedy grasses are tough, unpalatable, or otherwise undesirable for forage. Quackgrass possesses nearly all of the qualities desired in a hay plant, being palatable, nutritious, prolific, hardy, leafy, easily harvested, and adapted to wide variations of soil and climate. Were it not for the difficulty of controlling the grass in rotation areas, it might well have become one of the standard forage grasses of North America. (Fig. 14.)

Although not cultivated to any extent, quackgrass is an important element in commercial hays in nearly all of the large eastern hay markets. Probably 50 per cent or more of the timothy and mixed hays which enter the Boston market contain from 5 to nearly 100 per cent of quackgrass. Similar conditions are found in the markets of New York, Philadelphia, and Buffalo, the percentage of admixture being largest in the hays from the Eastern States and scarcely noticeable in the better grades of timothy hay from the Middle West. Apparently, dealers do not discriminate against timothy containing quackgrass except to grade the product as mixed hay. The indications are that many dealers are unable to distinguish between real timothy and quackgrass.

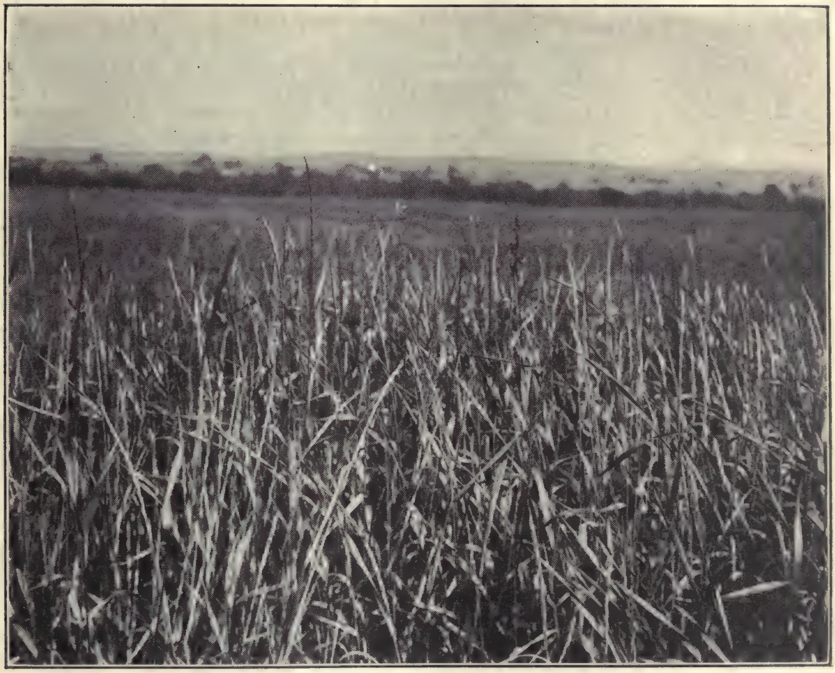

FIG. 14.—A field of mixed timothy and quackgrass for hay. The quackgrass is somewhat stiff and rough, but makes a good forage where it occurs abundantly.

In appearance and feeding value quackgrass hay closely resembles ordinary timothy hay. The stems of quackgrass are somewhat stiffer and coarser than timothy, the color is paler, and the leaves are rougher, but the differences are not so pronounced that the two can be readily distinguished in a mixed lot. Cattle, horses, and sheep will eat a mixture of quackgrass and other grasses without showing any preference, but all animals will reject the grass if it is cut so late that the dried stems are hard and tough.

The chemical analyses of quackgrass as compared with that of the standard hay grasses are presented in Table 1.

TABLE 1.—*Chemical analysis of quackgrass compared with other grasses.*[1]

Forage grass.	Chemical composition.							Digestible nutrients in 100 pounds.		Nutritive ratio.
	Water.	Ash.	Protein.	Crude fiber.	Carbohydrates.	Fat.	Total dry matter.	Protein.	Carbohydrate equivalents.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	
Quackgrass	12.5	6.6	9.3	23.0	45.8	2.8	87.5	5.4	48.1	8.9
Timothy	12.5	5.4	6.8	28.3	44.3	2.7	87.5	3.3	44.7	13.5
Redtop	8.9	5.2	7.9	28.6	47.5	1.9	91.1	4.8	49.1	10.2
Orchard grass	9.9	6.0	8.1	32.4	41.0	2.6	90.1	4.9	45.5	9.3
Oat-grass	8.1	6.4	9.4	29.8	43.6	2.7	91.9	4.1	43.2	10.5
Oat hay	11.0	6.8	7.9	29.6	41.9	2.8	89.0	4.2	41.7	9.9
Western brome-grass	5.8	8.4	8.4	32.2	42.9	2.3	94.2	4.3	48.3	11.2
Johnson grass	9.0	7.0	8.2	29.7	43.4	2.7	91.0	3.6	47.0	13.0
Crabgrass	9.0	8.2	7.0	30.1	43.3	2.4	91.0	4.1	50.4	12.3

[1] Analyses by the Bureau of Chemistry, United States Department of Agriculture. Owing to the limited number of requests for information on quackgrass, only four analyses of the plant have been made by the Bureau of Chemistry. Other investigators, also working with a limited number of specimens, have reported a somewhat lower protein content, higher fiber content, and a narrower nutritive ratio than the figures here given.

Quackgrass should be harvested for hay not later than the early blossoming stage, ordinarily about 10 days before it is time to cut timothy. Early cutting eliminates the danger of harvesting viable quackgrass seeds and ergot. The yield of quackgrass hay from a new meadow is from 1 to 2 tons to the acre, approximately the same as that of an ordinary timothy meadow. In the region south of the Great Lakes a second or even a third cutting can be harvested during wet seasons.

Quackgrass meadows are unusually free from weeds, owing to the vigorous growth of the grass and to the fact that it is cut early, before weeds have a chance to go to seed. Such common meadow weeds as oxeye daisy, wild carrot, and fleabane are seldom associated with quackgrass.

One disadvantage of quackgrass from the standpoint of hay production is the fact that it becomes root-bound. As the plant becomes root-bound the yield falls off rapidly, usually decreasing from one-quarter to one-half the second year and almost disappearing by the third or fourth year. The meadow may be restored to maximum production, however, by stirring the sod vigorously in the spring by means of shallow plowing, thorough double disking, or harrowing with a spring-tooth harrow. The matted rootstocks are thus torn to pieces and stimulated to produce a vigorous growth of leaves, so that in a few weeks the grass is in as thrifty a condition as ever. When handled in this way a quackgrass meadow may be maintained almost indefinitely without the expense of the periodic reseeding necessary with other grasses. Like all grasses, quackgrass responds to the use of fertilizer, and often a yearly top-dressing of barnyard manure or a light application of sodium nitrate, sulphate of ammonia, or other nitrogenous material is profitable. On some soils it pays to use phosphate fertilizers.

Mixtures of quackgrass and other grasses are more common and more desirable than quackgrass alone. Although a sod grass, quackgrass often grows in irregular patches rather than in solid stands, and it is well to have other grasses to fill the bare spots in the field.

Orchard grass is especially well suited for mixing with quackgrass, as the two mature about the same time. Perennial rye-grass, tall meadow oat-grass, and meadow fescue also do well as companion crops. The plants most commonly associated with quackgrass are timothy, red clover, alsike clover, and redtop. Alfalfa and quackgrass make a very good mixed hay, although the quackgrass tends to run out the alfalfa in two or three years if the seed bed is not free from the grass at the time the alfalfa is planted.

One way of handling quackgrass land is to sow the field to sweet clover, which by its rank growth forces the quackgrass to grow taller, while the grass lightens the clover hay, making it more easily cured and adding somewhat to its palatability. To prepare for the sweet clover, the quackgrass is double disked early in the spring and seeded immediately with from 12 to 15 pounds an acre of hulled and scarified sweet-clover seed. The seed is sown broadcast and covered by rolling rather than harrowing. One cutting of quackgrass and one of mixed grass and clover are obtained the first year, and two cuttings of mixed hay the second. The yield of each cutting averages about 2 tons an acre on good land, which is more than either crop would yield alone. Since sweet clover is a biennial plant, it fits in very well with the rejuvenation process required for quackgrass.

USE FOR PASTURAGE.

Quackgrass is not as abundant in pastures as in meadows, owing to its tendency to become sod-bound and disappear, but where it occurs it is a good grazing grass. It starts growth earlier in the spring than bluegrass or redtop and continues to furnish green pasture until late in the fall. It withstands hot, dry weather as well as or better than bluegrass and makes more growth on sandy soils or soils poor in lime. A good sod of quackgrass bears close grazing by cattle, although sheep sometimes injure it by too close nibbling.

A quackgrass sod must be rejuvenated every two or three years. If other grasses predominate in the pasture, however, usually it is not advisable to disturb the sod simply for the sake of encouraging the quackgrass. As quackgrass when fully matured is not eaten by live stock, the area should be closely pastured or kept closely mowed to induce the development of new leaves.

A rather unusual form of pasturage is furnished by the rootstocks, which are sweet, succulent, nutritious, and relished by hogs and sheep. The animals may be turned on a newly plowed field to graze, or the rootstocks may be raked off and fed like hay. During the latter half of the season the rootstocks often contain more nutriment than the aboveground portions of the plant. In Europe the rootstocks are fed to animals rather than burned or thrown away. Some caution should be used in feeding them, as they have a diuretic effect and may be harmful if fed in excess.

USE AS SILAGE.

Almost any combination of quackgrass and a leguminous forage crop can be used successfully as silage. Often a field of mammoth clover which has become infested with quackgrass can be saved by putting the crop into the silo when it is too old and hard to make good hay. The quality and keeping properties of pea waste from canneries, which is often ensiled, are improved by the presence of quackgrass. Quackgrass does not make good silage by itself unless cut while very green, since the mature crop is not sufficiently succulent. One advantage of ensiling quackgrass is that the seeds are killed in the process.

USE IN LAWNS.

As would naturally be expected, much quackgrass finds its way into lawns in the quackgrass regions. A closely mowed quackgrass sod makes a dense turf, somewhat coarser than that of bluegrass or the bent-grasses, but finer than that of crabgrass or timothy. (Fig. 15.) The herbage is of a pleasing dark-green shade that retains its color from early spring until late fall. In parts of New England and the Middle Western States quackgrass is one of the most useful of lawn grasses, and a careful examination of the most attractive lawns often discloses a high percentage of this species. On sandy soils in Michigan it has been the most successful turf grass for golf courses and other much-used surfaces.

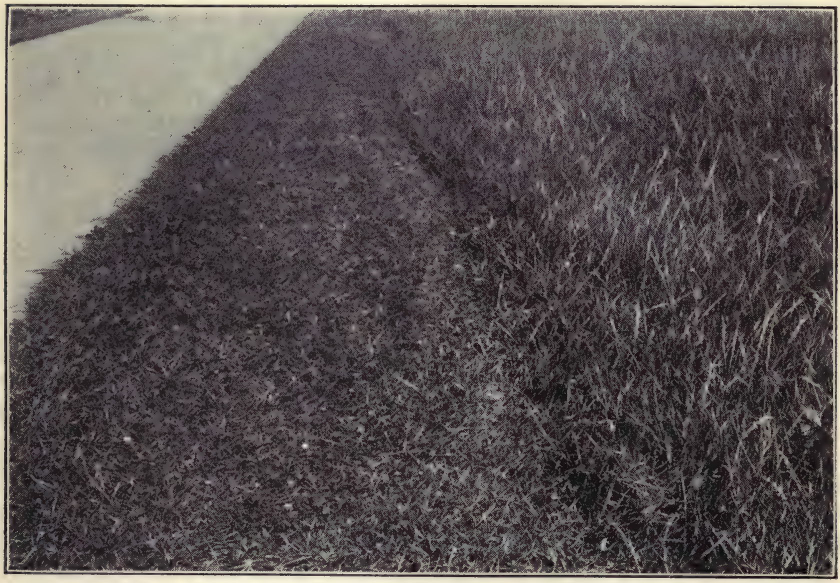

FIG. 15.—A lawn of mixed quackgrass and bluegrass. The quackgrass is coarser than the bluegrass, but remains green in hot weather and makes a pleasing turf.

USE IN ROTATIONS.

Because of the fact that quackgrass must be plowed occasionally to maintain the vigor of the sod, it can be worked in to good advantage with short rotations. One of the best of these is quackgrass and buckwheat. When the sod shows signs of deterioration, the field can be plowed shallow and harrowed once, soon after haying. Except in the extreme northern part of New England, buckwheat can then be planted in time to produce a profitable crop before frost. The buckwheat should not be planted thick enough to injure the grass by shading, 3 pecks of seed to the acre being sufficient. Some growers make a practice of seeding from 4 to 6 pounds of perennial rye-grass or tall meadow oat-grass with the buckwheat in order to insure a good meadow, the quackgrass, of course, taking care of itself.

Quackgrass is also grown in rotation with fodder corn, the sod being plowed shallow in the fall and left rough over winter, so that the grass will not smother the corn in the spring. Almost any crop that makes a quick, rank growth can be grown in rotation with quackgrass, provided it does not occupy the land for more than three or four months.

USE AS A SOIL BINDER.

The tough interlacing rootstocks of quackgrass are very useful for holding the soil on railroad embankments, terraces, gullies, river banks, and hillsides that tend to wash. The plants are readily propagated either from seed or from cuttings of the rootstocks, the cuttings being preferred, because the young plants thus become firmly rooted more quickly. Either the seeds or rootstocks are best planted in early spring in shallow trenches dug about 1 foot apart across the face of the slope.

USE IN MEDICINE.

The prepared rootstocks of quackgrass are used in the drug trade under the name of dog-grass, Triticum, and radix graminis. Quackgrass is officially recognized by the pharmacopœias. About 250,000 pounds of dog-grass are used annually in the United States, the bulk of the supply in pre-war years coming from Germany, where the average importing wholesale price was from 2½ to 7 cents per pound. Since 1914 the price paid by jobbers for well-prepared stock has fluctuated from 10 to 20 cents a pound, and the demand has been met by supplies from this country. The available supply of quackgrass, however, exceeds any possible demand, and the market could easily be overloaded. Doubtless a limited opportunity will remain for persons to gather and sell the rootstocks, but the current demand should be determined before engaging in the business.

In preparing the drug the fresh rootstocks are gathered in the spring, washed carefully, and the rootlets and scales removed. The rootstocks are then cut into pieces about one-third of an inch in length, thoroughly dried, and packed in clean bags for shipment.

USE AS FOOD.

Both the seeds and rootstocks of quackgrass have been used in times of emergency for food. The seeds yield a fair quality of flour, similar in appearance to rye flour. When gathered in the spring or fall the rootstocks can be ground into flour, which produces a rather heavy, light-colored bread. During the World War this material was used quite freely in southern Bavaria, where it was declared superior to most wheat substitutes. Neither the seed flour nor the rootstock flour is of the highest quality, and its preparation is somewhat laborious, but it is nutritious and not unpalatable.

Decoctions or teas made from the dried rootstocks are well known in central Europe, where they are thought to have a slight nutritive as well as medicinal value. A coffee substitute has also been prepared from the roasted rootstocks. Attempts to utilize the rootstocks in the production of commercial alcohols and sugars and as a substitute for barley in malting have not proved successful.

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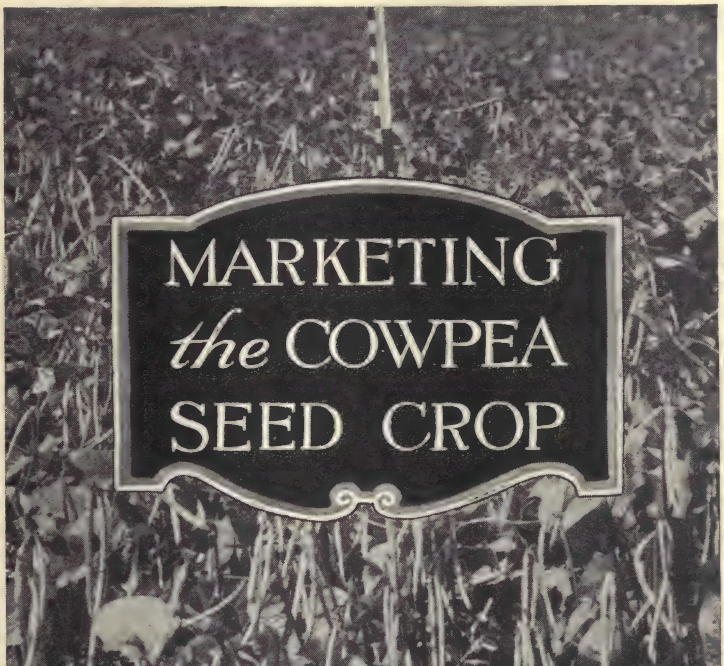
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1308

MARKETING *the* COWPEA SEED CROP



1862 1889

MARKETING THE COWPEA SEED CROP.

By J. E. BARR, *Investigator in Marketing Seeds, Bureau of Agricultural Economics.*

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VALUE OF THE CROP.

The annual farm value of cowpeas[1] produced in the United States during recent years averages over $18,000,000. On most farms, however, the cowpea is grown largely as a catch crop, is considered of secondary importance as a money crop, and in many instances is handled in an unbusinesslike manner. This results not only in a direct monetary loss to the grower, but may mean a more serious economic loss to the farmers desiring to purchase cowpea seed.

The cowpea is of major economic importance in the crop rotation, especially in the Cotton Belt, but it is an uncertain producer of seed, and in some years there is an apparent shortage of stocks for planting purposes. Investigations show that almost invariably a lack of cowpea seed in any section may be attributed to inefficient farm preparation for market and inequitable distribution of existing stocks rather than to insufficient production. This bulletin points out some of the methods by which growers may conserve their surplus production of cowpeas, prepare them for market, and sell them in such a way as to return a greater net profit for themselves and to provide an adequate supply of good-quality stocks for farmers who find it necessary to buy.

THE COMMERCIAL SUPPLY.

It has been estimated that normally 250,000,000 to 300,000,000 pounds of cowpeas are required for planting annually. An extensive inquiry made by the Federal Bureau of Markets, the results of which were published in the Seed Reporter,[2] indicated that of this quantity approximately 30 per cent, or 75,000,000 to 90,000,000 pounds, is obtained by farmers from various dealers; 15 per cent, or 37,500,000 to 45,000,000 pounds, is obtained direct from growers; and 55 per cent, or 137,500,000 to 165,000,000 pounds, is produced on the farms where used.

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[1] The term "cowpeas" as used in this discussion does not include "blackeye cowpeas or beans" grown in California.

[2] See Seed Reporter, vol. 3, No. 4, Oct. 11, 1919.

Issued, January, 1923.

Considering that portion of the requirements which is obtained by farmers direct from growers, as well as that bought from dealers, as commercial seed, the total annual commercial supply averages 125,000,000 pounds. This represents the production from about 125,000 farms, based on the information given in Table 1, which shows the average production of cowpeas per farm in the United States to be only 1,010 pounds.

TABLE 1.—*Average production of cowpeas per farm by States.*[1]

State.	Production per farm.	State.	Production per farm.
	Pounds.		*Pounds.*
Alabama	900	Mississippi	865
Arkansas	760	Missouri	1,560
Delaware	2,200	North Carolina	750
Florida	1,620	Oklahoma	1,130
Georgia	1,065	South Carolina	1,060
Illinois	2,170	Tennessee	755
Indiana	1,840	Texas	1,550
Kentucky	1,200	Virginia	1,150
Louisiana	1,045	United States, average	1,010
Maryland	1,870		

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[1] These figures are computed from the agricultural reports of the Bureau of the Census. There is no consistent ratio between the production per farm and the total production by States. The States showing the lowest production per farm in most instances show the largest total production because of the greater number of farms producing this commodity. These figures are published by the Bureau of the Census for "dry peas," which includes "cowpeas." For the States given in the table the amount is made up almost wholly of "cowpeas."

These figures serve to indicate the difficulty of assembling large shipments, the average surplus of 30 farms being required to make a minimum carload. The small lots available on each farm must be either concentrated for carload shipment to consuming territory for redistribution or sold and shipped or delivered in small quantities direct to other farmers.

SURPLUS PRODUCING AREAS.

Most of the commercial supply of cowpeas is produced in Alabama, Georgia, South Carolina, North Carolina, and Mississippi. Other States that produce fairly large quantities but usually not enough to meet their own planting requirements are Florida, Virginia, Tennessee, Louisiana, Texas, Oklahoma, Arkansas, Missouri, Illinois, Indiana, Ohio, and Kentucky. The relative importance of the various producing areas in 1919 is illustrated in Figure 1.

Production varies in any producing area from year to year, largely because of unfavorable weather conditions, or a large acreage may be planted for seed production and there may be a shortage of labor. If heavy demands are made upon the labor supply for handling the staple crops the cowpea seed crop may remain unharvested or may be grazed by live stock. Even after a crop is harvested the prevailing prices may not be attractive to farmers and they may consider it more profitable to use their cowpeas on the farm. Hence a large acreage or a heavy production of cowpeas does not necessarily mean that an increased quantity will enter commercial channels.

VARIETIES AVAILABLE.

The leading commercial varieties of cowpeas are Whippoorwill or "Whips," Clay, Brabham, Iron, New Era, and "mixed." Each of these varieties or classes possesses a different degree of adaptability for planting in sections of varying latitude and climatic conditions and each has a distinct commercial value. Surplus quantities of some of these varieties are produced in more or less restricted areas. In order to ascertain what percentage of the total quantity of cowpeas shipped from the surplus producing areas in each State is represented normally by each variety, an extensive inquiry was made among shippers of this commodity in 1919. The results, published in the Seed Reporter for April 5, 1919, are shown in Table 2.

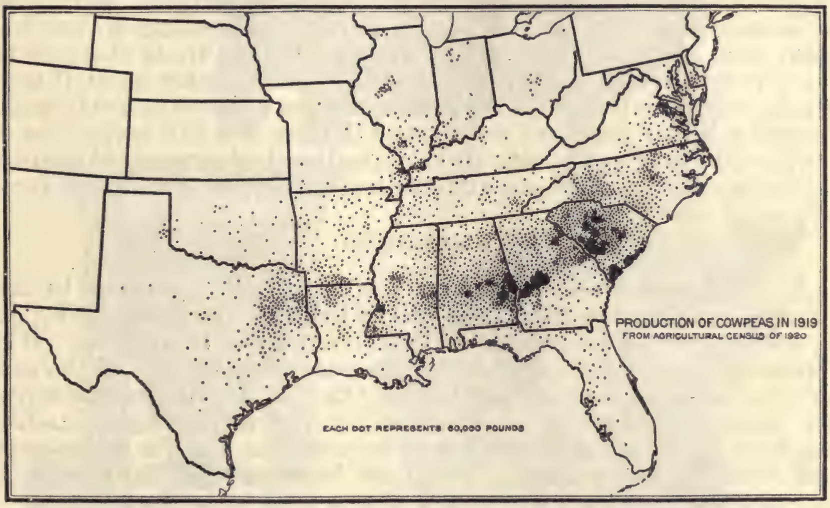
PRODUCTION OF COWPEAS IN 1919
FROM AGRICULTURAL CENSUS OF 1920
EACH DOT REPRESENTS 60,000 POUNDS

FIG. 1.—Map showing the relative importance of various producing areas of cowpeas.

TABLE 2.—*Shipments of cowpeas from surplus producing areas by varieties, expressed in percentage of total shipments.*

State.	Variety or class.							
	Black-eye and White.	Whip-poor-will.	Clay.	New Era.	Iron.	Brab-ham.	Mixed.	All other varie-ties
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Alabama	10	38	18	4	(1)	(1)	28	2
Arkansas	1	94	1				3	1
Delaware	6	13	25	18			38	
Florida	1	13	3		27	52	4	
Georgia	3	24	10	(1)	16	23	22	2
Illinois		49		27			23	1
Indiana		85	4	4			7	
Kentucky	11	80	2	2			5	
Louisiana	1	33	21	1			44	
Maryland		60		20			20	
Mississippi	2	48	24	3			23	
Missouri	1	38	1	45			15	
North Carolina	11	25	14	2			44	4
Oklahoma	23	48	8	15			6	
South Carolina	4	20	20	1	2	2	47	4
Tennessee	5	58	14	4			18	1
Texas	15	78	2	3			2	
Virginia	15	25	6	3			35	16
Average for above States	5	42	14	4	3	5	25	2

[1] Less than 1 per cent.

FARM PREPARATION TO INCREASE VALUE.

The loss to farmers through the improper handling and preparation of cowpeas is difficult to estimate. The wide margin between the average price received by growers and that paid by consuming farmers, however, indicates somewhat the possibilities of adding to the farm value. This margin between buying and selling prices represents, in the main, services performed, many of which can be rendered more economically by the growers on the farm. Any effort on the part of growers to improve the quality of their cowpeas increases the probable price to themselves. As long as growers place cowpeas on the market that are mixed, poorly thrashed, weevil eaten, and sacked in second-hand bags, and as long as farmers are willing to buy and plant such cowpeas, there will be opportunities in trade channels for sharp practices and unjustifiable profits. On the other hand, if there is a concerted endeavor on the part of cowpea growers to produce and market a better product for seed, and if there is a full realization on the part of farmers generally of the agricultural advantages of planting higher-grade seed, cowpeas will attain their proper place in the farmer's list of money crops.

THRASHING.

Although some farmers harvest and thrash their cowpeas by machinery, most of this crop is still picked by hand and either flailed out by hand or hulled on a small, inexpensive pea and bean huller. This condition is another result of the secondary importance of the crop and the small production per farm. On most farms where cowpeas are produced there is no demand for harvesting and thrashing machinery that could be used both for cowpeas and for other crops, and, with few exceptions, it would not be economical for growers to purchase the necessary machinery of this type for cowpeas alone.

Types of machinery and methods used in harvesting and thrashing large fields of cowpeas for seed have been discussed in a previous publication of the Department of Agriculture.[3]

For hulling or thrashing cowpeas that have been picked by hand a small pea huller may be purchased at relatively low cost which does much more effective work than is done by flailing. Such a machine is operated by hand or power. A uniform speed of both the cylinder and fan shaft is desirable and can be maintained more satisfactorily when power is used. The pods should be thoroughly dry before attempt is made to hull them. Best results are obtained when thrashing is done on a sunny day following three or more days of fair weather, because the hulls tend to absorb moisture during periods of cloudy and rainy weather, even though they may be stored in a dry place, and are difficult to break open. Cowpeas hulled or thrashed properly on a machine of this kind contain less foreign matter than when flailed out by hand. They are subjected to screen and air-blast separations which remove most of the hulls, chaff, dirt, and broken and very light-weight seeds. Types of hullers in this class, and which are believed to be the most economical for the average cowpea grower, are illustrated in Figure 2.

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[3] Morse, W. J.: Cowpeas: Utilization. U. S. Department of Agriculture, Farmers' Bulletin No. 1153, 1920.

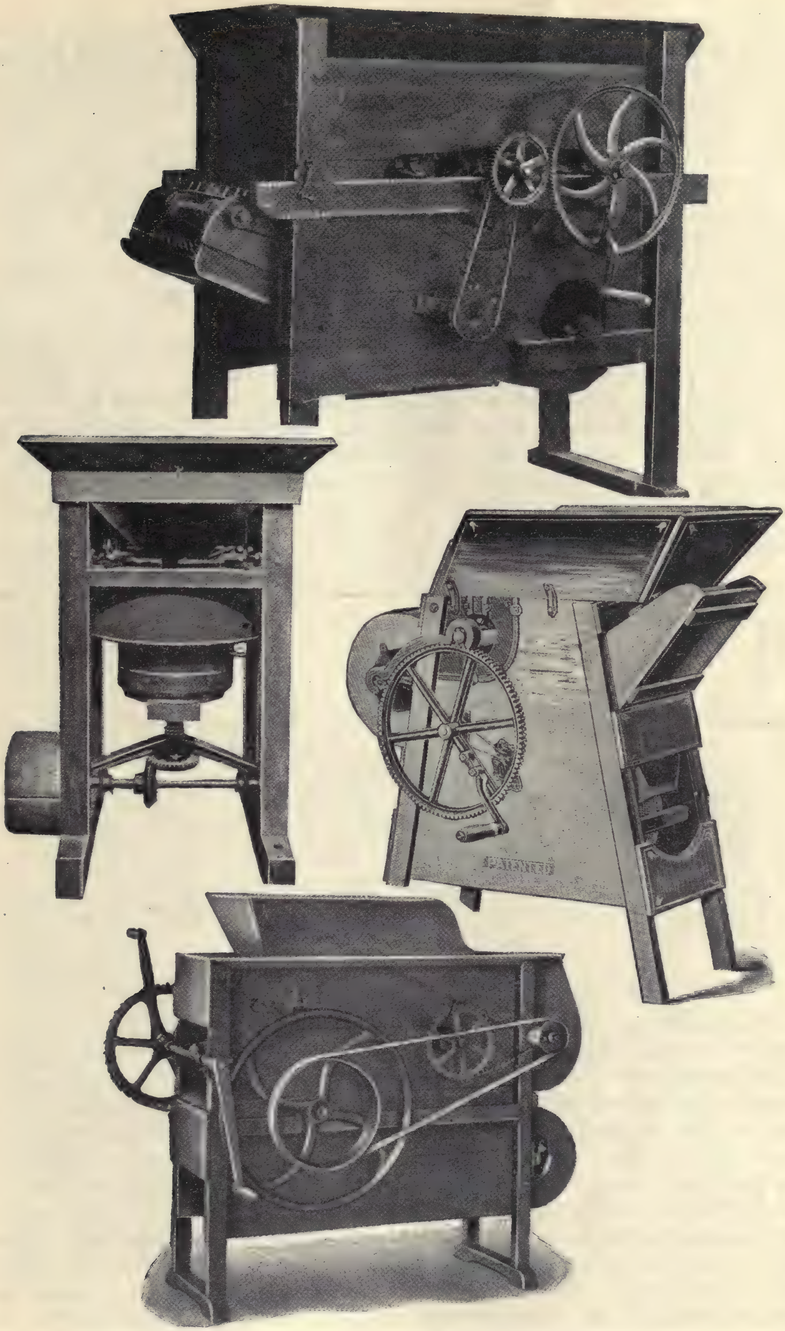

FIG. 2.—Types of hullers used for hulling cowpeas.

RECLEANING.

The value of cowpeas may be improved by recleaning after thrashing or hulling. This is especially true of cowpeas flailed out by hand. If a small huller, as illustrated in Figure 2, is used, the cowpeas may be run through it a second time to remove more of the foreign matter remaining after the hulling operation. A more thorough job of recleaning, however, may be done on a small cleaning machine that can be purchased at a cost of $40 to $50.[4] Such a machine may be used to advantage for cleaning other kinds of seeds as well as cowpeas and should prove a profitable investment on most farms.

In preparing cowpeas for market it is well for the grower to keep in mind the quality of seed he would like to get were he to buy cowpeas for planting and to endeavor to bring his product up to this high standard. A high-quality product usually commands a high price. Cowpeas are no exception to this rule in spite of the fact that they sometimes are accorded an inferior place in the list of farm crops. To show more clearly what can be accomplished by recleaning cowpeas, samples were collected from various producing sections and analyses made to determine the percentage of foreign matter present. The results are given in Table 3 and illustrated in Figures 3 and 4.

TABLE 3.—*Inert matter present in samples of cowpeas, and value compared with clean seed.*

Sample No.	Variety.	Pure seed.	Inert matter.[1]	Value compared with clean seed at $4 per 100 pounds.
		Per cent.	*Per cent.*	
1	Brabham	96.5	3.5	$3.86
2	Unknown	87.5	12.5	3.50
3	Mixed	91	9	3.64
4	Iron	81.5	18.5	3.26
5	Brabham	98.5	1.5	3.94
6	Mixed	97.2	2.8	3.89
7	Whippoorwill	99	1	3.96
8	Clay	99	1	3.96
9	Whippoorwill	98	2	3.92
10	Mixed	98.5	1.5	3.94
11	Brabham	96	4	3.84
12	Whippoorwill	95	5	3.80

[1] Inert matter includes broken seeds, dirt, stones, sticks, chaff, and other similar material.

Practically all of the foreign matter and light-weight and broken seeds in the samples analyzed could have been removed on the farm by running the cowpeas through a small cleaning machine. The farm is the logical place for recleaning cowpeas, because the screenings can be utilized more profitably by the grower for feeding to live stock than by any other agency. Before cowpeas can command the highest price they must be recleaned, and the increased price justly goes to the person or agency performing such service. The impression prevails among some growers that recleaning is not necessary because they apparently obtain as high price for their stocks without recleaning. This may be true to a limited extent, but the fact remains that if the standard of value for cowpeas is ever to be raised so that growers may hopefully expect a higher price for their product the quality must be improved.

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[4] Edler, G. C.: Seed Marketing Hints for the Farmer. U. S. Department of Agriculture., Farmers' Bulletin No. 1232, 1921.

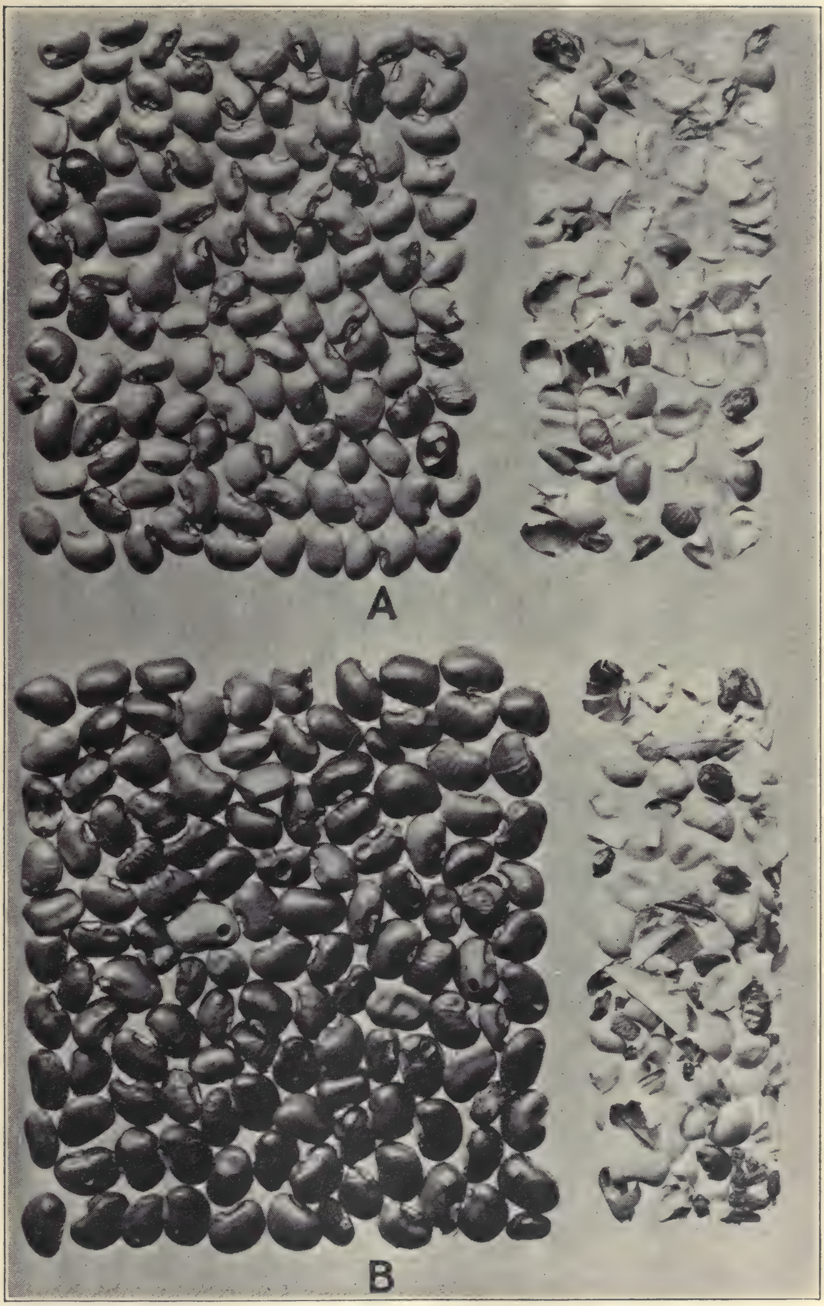

FIG. 3.—Cowpeas (*A*) machine-thrashed containing 18.5 per cent broken seeds by weight: (*B*) contains 12.5 per cent broken seeds and chaff. All natural size.

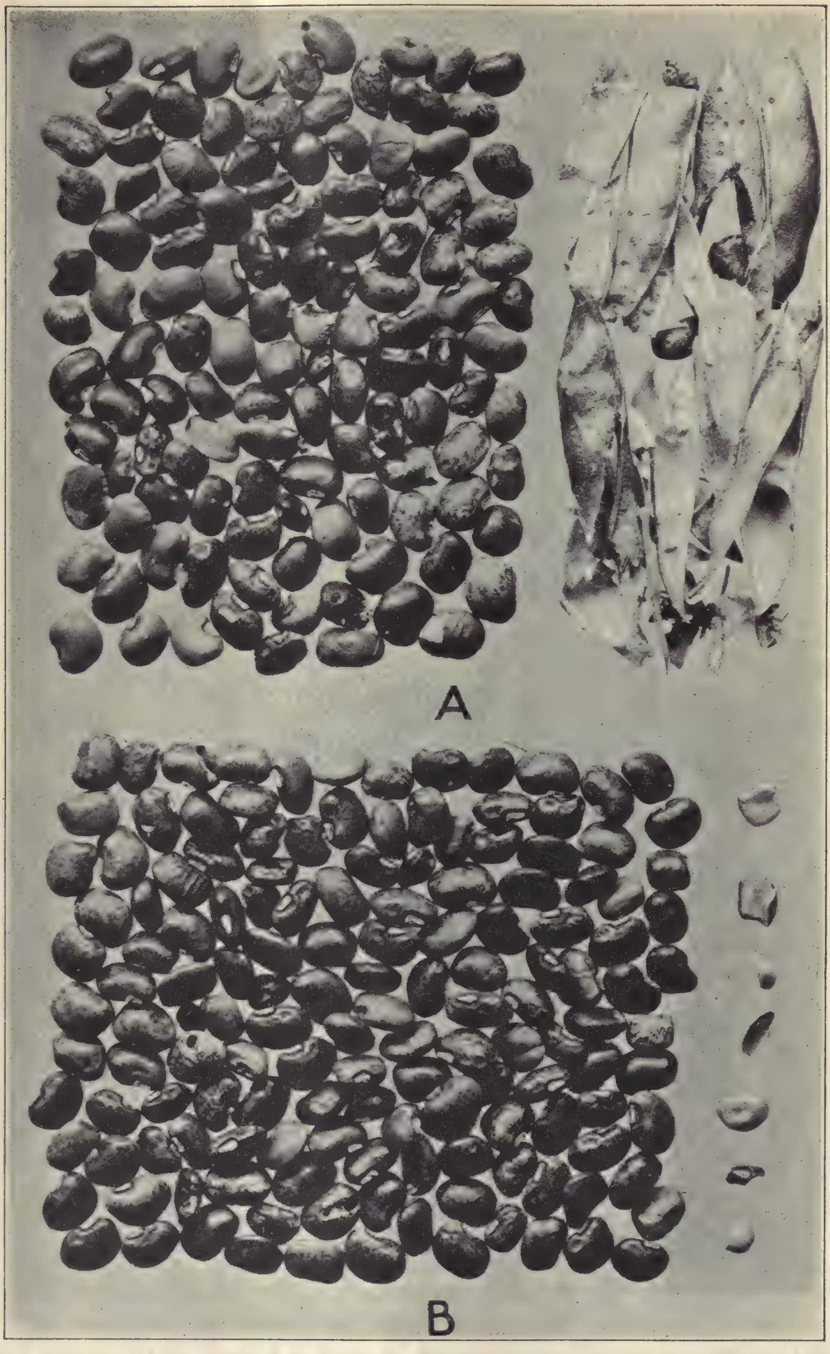

FIG. 4.—Cowpeas (*A*) thrashed or flailed out by hand, containing 9 per cent inert matter, mostly hulls; (*B*) machine-thrashed, free of chaff and dirt, and containing only 1 per cent broken seeds by weight. All natural size.

The last column in Table 3 shows the value of 100 pounds of cowpeas, like sample, when recleaned stock is worth $4 per 100 pounds. On this basis the value of sample No. 4 is 74 cents per 100 pounds less than the value of clean seed. In this case the loss is occasioned almost wholly by the presence of broken seeds. (See Fig. 3, A.) The cowpeas from which this sample was taken were thrashed or hulled by machinery. Such a large percentage of broken seeds, however, shows that the machine was carelessly operated. By operating the thrasher or huller at the proper speed and, if necessary, by making other simple adjustments as recommended by the manufacturers, this loss may be prevented.

The inert matter in sample No. 3 is composed principally of hulls and chaff. (See Fig. 4, A.) This lot was flailed out by hand and was not cleaned as thoroughly as it might have been, although no cleaning machine or fanning mill was available. Nine pounds of such inert matter were present in each 100 pounds and, if clean cowpeas were selling at $4 per 100 pounds, this lot was worth only $3.64 per 100 pounds. The reduced value is reflected in the price received by the grower and the maximum price may reasonably be expected only when the stocks for sale have been recleaned properly. It will be noted that samples No. 7 and No. 8 contain only 1 per cent of inert matter and, on the basis of $4 per 100 pounds for clean seed, are worth $3.96 per 100 pounds. All hulls and chaff were cleaned out and only an insignificant quantity of broken seeds is present as illustrated in Figure 4, B. Any one or all of the samples shown in Table 3 could have been cleaned on the farm as thoroughly as sample No. 7 and the price to the grower increased accordingly.

SACKING.

Heavy losses are incurred through shipping cowpeas in poor bags, improperly or insecurely tied or sewed, and complaints on the part of dealers regarding the poor condition of shipments on arrival from this cause are frequent. Adjustments in cases of this kind are difficult and the grower usually is at a disadvantage and suffers the greater loss.

Cowpeas should be sacked in new even-weight bags, preferably of 100 pounds capacity. Secondhand bags may serve the purpose, provided they are strong and in good condition. The bags should be of 10-ounce burlap, or heavier, although a more expensive seamless cotton bag may be used if desired. They should be sewed or tied with strong twine.

It is a common thing for growers to market their cowpeas locally in all sorts of containers—sacks, barrels, boxes, or any receptacle that will enable them to get the cowpeas to the shipper's warehouse. The cowpeas are poured into bins and in some cases the various containers are returned to their owners. Before making a shipment it is necessary for the shipper to reclean, if this service has not been performed by the grower, and resack the entire lot. The service of sacking necessarily carries a cost with it and the agency rendering the service is entitled to reimbursement. By performing this service on the farm the grower will receive an increased price for his cowpeas. His product will be more attractive in appearance and in a readily salable condition.

STORAGE.

Cowpeas should be stored in a dry place and protected from weevils and rodents. It is a common practice in the cotton States to pick the pods by hand and store them until the winter months before thrashing or hulling. There is probably an advantage in this arrangement in that it defers the hulling until after the rush field work of harvesting other crops. On the other hand, there are many more advantages in thrashing or hulling cowpeas as soon as thoroughly dry, and in recleaning and storing them in sacks. The principal advantages accruing from this procedure are: Less storage space is required; the straw, hulls, and screenings are available for feeding to live stock or for other disposition; the bags are easily transferred from place to place if desired and sales may be made at an opportune time with the least possible delay; and the cowpeas may be treated promptly and effectively with carbon disulphid to destroy any weevils or other insect pests present, thereby preventing serious loss from this source.

The treatment with carbon disulphid is of major importance because of the susceptibility of cowpeas to weevil damage. From 6 to 10 months elapse between the time cowpeas are harvested and the time they are needed for planting the following season. Most of the cowpeas are harvested during the months of August, September, and October, as shown in Table 4.

TABLE 4.—*Percentage of cowpeas harvested monthly.*[1]

State.	June.	July.	August.	September.	October.	November.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
North Carolina	....	3	10	39	30	18
South Carolina	....	4	15	36	35	10
Georgia	2	7	23	42	22	4
Alabama	....	10	26	43	20	1
Mississippi	1	6	21	36	28	8
Louisiana	1	7	20	45	27	....
United States	.9	7.6	21.8	41.1	23.8	4.8

[1] Adapted from Monthly Crop Reporter, September, 1920.

The movement from growers' hands begins around November 1, increasing in volume through December, January, and sometimes February. On the average, about 40 per cent of the previous year's crop is sold by growers before January 15. The percentage of the total commercial supply of cowpeas of a given year's crop that had moved from growers' hands up to a specific date the following January is shown in Table 5.

TABLE 5.—*Percentage of cowpeas that moved from growers' hands up to a specific date.*

Crop.	Date.	Per cent.
1921	Jan. 28, 1922	69
1920	Jan. 15, 1921	41
1919	Jan. 15, 1920	44
1918	Jan. 15, 1919	31
1917	Jan. 1, 1918	24

The heaviest demand from farmers, however, is during the late spring and early summer months. This illustrates the long period over which cowpeas must be carried. It gives ample time for recleaning the stocks and transporting them from producing to consuming sections. They must be stored during much of this period, however, and this fact, together with the warm weather prevailing in the more important producing sections, increases the chances of weevil infestation, and some effective means of reducing such injury is essential if the cowpeas are to be of high quality for seed.[5]

GERMINATION OF SEED.

The value of cowpeas for seed purposes is directly affected by the percentage that will grow. Germination is as important in cowpeas, from the standpoint of the farmer who buys them for seed, as in other field crop seeds. There may be those, among both growers and consumers, who do not appreciate this fact, but it is obvious that cowpeas that will not grow are of no more value for planting purposes than any other kind of dead seed.

A realization of this fact by growers who produce cowpeas for market is all the more important when it is remembered that by far the larger percentage entering commercial channels is sold and used for seed. Furthermore, cowpeas unfit for seed and sold for feed command a very low price, while stocks that are pure as to variety, recleaned, and high in germination are most valuable for seed and sell at the highest price.

When harvest is delayed because of continued rains, cowpeas almost invariably are of low germination. The damage from this cause is clearly visible and may be so great as to make the cowpeas not worth harvesting. Cowpeas that are harvested promptly at maturity, thrashed when properly cured, stored in a dry place, and protected from weevil or other insect injury are usually of high viability. The percentage of germination, however, should not be assumed. A test is always advisable before offering cowpeas for sale. When advertised for sale or delivered by a common carrier, for seed, a number of States having seed laws (see p. 19) require that the percentage of germination, together with other information, be shown on the tag or label attached to each bag or other container.

MARKETING COWPEAS.

The cowpea market is one of uncertainty and is rife with petty speculation. It would seem to be a simple task to collect the surplus stocks from heavy-producing areas and redistribute them among farmers in consuming territory. The unstable market is due largely to the variation in demand and uncertainty of production in any section from year to year. The demand is limited and is affected by the buying power of the farmers, the quality of the crop for planting purposes, and the comparative price and supply of seed of other crops, notably soy beans and velvet beans, which compete in the crop rotation.

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[5] Back, E. A., and Duckett, A. B.: Bean and Pea Weevils. U. S. Department of Agriculture, Farmers' Bulletin 983, 1918. Hinds, W. E.: Carbon Disulphid as an Insecticide. U. S. Department of Agriculture, Farmers' Bulletin 799, 1917.

As has already been emphasized, production is small per farm and the surplus to be marketed is difficult to determine. The United States Department of Agriculture issues a report each year, during November, which shows the comparative acreage, yield, and price of the new crop. At intervals of two or four weeks thereafter during the months of December, January, and possibly February, when the

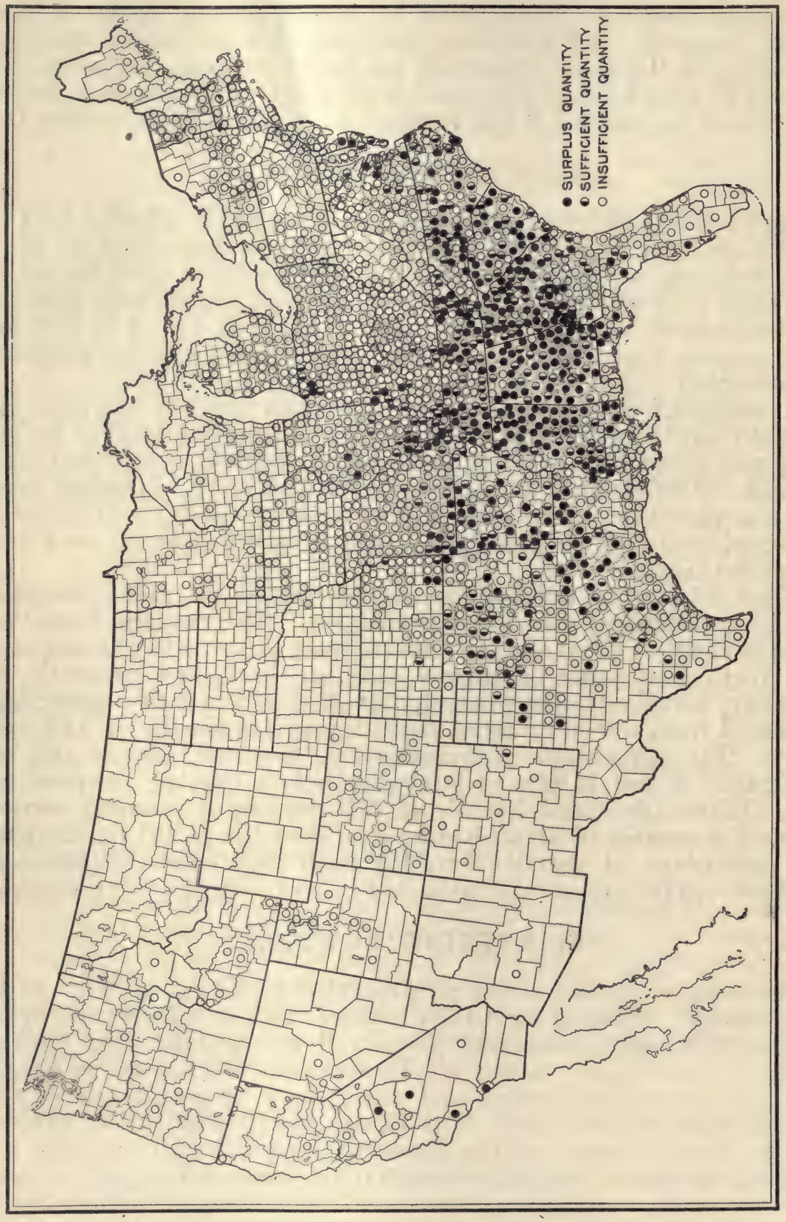

FIG. 5.—Map showing the normal consuming and surplus producing areas of cowpeas.

bulk of the cowpeas is sold by growers, reports are issued that indicate the percentage of the crop in various sections that has been sold, the prices paid, and the quality of the crop for seed. Wholesale selling prices quoted by dealers at the large terminal markets are issued by the department weekly from January 1 to May 31, inclusive. All of this information is available to growers, shippers, dealers, and consumers through the medium of "Weather, Crops, and Markets,"[6] and is intended to be a guide to all agencies in buying or selling cowpeas.

The surplus producing States of Mississippi, Alabama, Georgia, South Carolina, and North Carolina are probably the heaviest consumers of cowpeas. There are a number of counties in these States which do not produce a surplus and which ship in large quantities for seed from other counties. After the demand has been supplied within these States the net surplus finds an outlet in Louisiana, Texas, Oklahoma, Arkansas, Missouri, Tennessee, Illinois, Indiana, Ohio, Virginia, Maryland, Florida, and to a less extent in States farther north and east. There are also a few counties or localities in these States in which a surplus is produced, but for the most part this is consumed in neighboring territory. The areas which normally ship in cowpeas are shown in detail by counties, designated by open circles, in Figure 5.

The geographical preference for varieties is an important factor in the commercial distribution of cowpeas. The late-maturing, vine-producing varieties, such as Clay, Iron, and Red Ripper, are preferred in the Mississippi Delta and the Sugar Belt of Louisiana, and are distributed mostly through New Orleans. In the Northern and Eastern States the Whippoorwill, New Era, and other early maturing varieties are more in demand. Some of the principal wholesale distributing points for these varieties are St. Louis, Mo., Louisville, Ky., Baltimore, Md., Richmond, Va., and Chattanooga, Nashville, and Memphis, Tenn. The Brabham, Iron, and Victor are more desirable in the wilt-infected areas of the South because of their resistance to wilt and root-knot, and to a great extent have replaced other standard varieties on farms where these diseases prevail.

Given a product which has been prepared properly for the market and a mental picture of the consuming areas and varieties desired, the grower is interested to know how he may sell his product or get in touch with consumers in the territories where his varieties are preferred. There are four principal agencies through which a grower may sell cowpeas: (1) To neighboring farmers, (2) to local shippers, (3) to distant seedsmen, and (4) to distant farmers through farm paper advertising. The estimated percentage of growers who market their cowpeas by each of the various methods is shown in Table 6 and illustrated in Figure 6. The best method of selling for a grower will depend largely upon his location and the quantity of cowpeas for sale.

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[6] "Weather, Crops, and Markets" is issued weekly by the United States Department of Agriculture and is sent free to persons cooperating with the department by furnishing reports and other information or regularly to anyone desiring it upon receipt of the subscription price of $1 yearly. Remittances must be made to the Superintendent of Documents, Government Printing Office, Washington, D. C.

TABLE 6.—*Percentage of growers who market cowpeas through various agencies.*

Agency.	Per cent.	Agency.	Per cent.
Direct to neighboring farmers	38	Through farm paper advertising	21
To local shippers	21	To traveling seed buyers	4
To distant seedsmen	14	By advance growing contract	2

SELLING TO NEIGHBORING FARMERS.

In marketing cowpeas, growers should consider first the possible demand from other farmers in the neighborhood. A grower may produce a surplus of cowpeas and sell them to a local shipper or ship them direct to a distant seedsman, when local farmers would have bought them at possibly higher prices than were obtained. The result in such cases is that cowpeas have to be shipped back into the locality to supply the deficit and almost invariably at increased prices. Few localities where this crop is grown consume as many cowpeas as might be consumed economically and, in most instances, there is no one who can afford to pay more for cowpeas, if he needs them, than a farmer in the immediate neighborhood of the producer. This is true especially of States or sections where only a small percentage of the farmers produce a surplus of cowpeas, and many more farmers find it necessary to buy their seed supply.

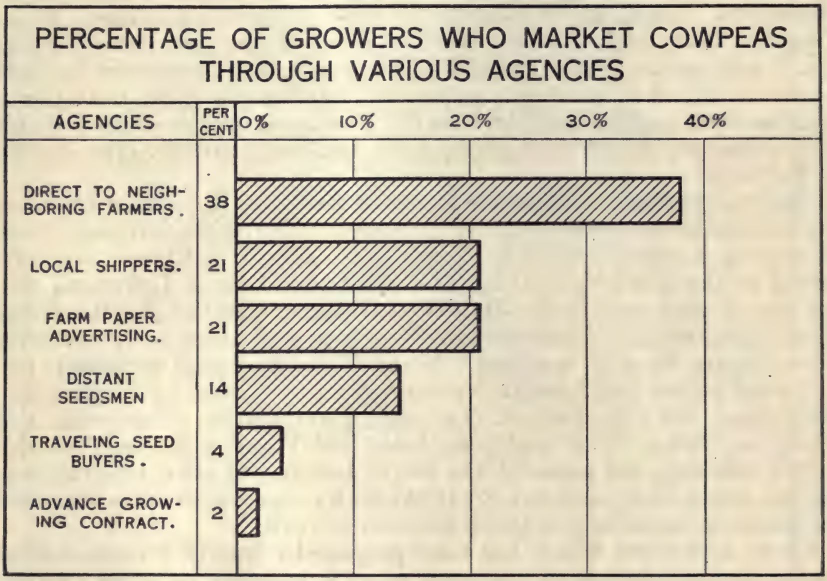

FIG. 6.—Chart showing percentage of growers who market their cowpeas through various agencies.

SELLING TO LOCAL SHIPPERS.

After supplying the local farm market, growers should consider the possibility of selling their cowpeas to local shippers. Usually such shippers are located in every town in sections where a surplus of cowpeas is produced. As shown in Table 6 and in Figure 6, 21 per cent of the growers market their cowpeas through this agency. The local shipper renders a service by assembling a number of small lots of cowpeas purchased from as many farmers, recleaning and resacking them if necessary, and shipping them in carload lots to distant wholesale distributing markets. He provides a ready market where growers may sell their product at any time and receive a prompt cash settlement. A minimum amount of the grower's time is occupied in the entire transaction. The shipper assumes the risk of losses in storage and of finding a satisfactory market. For these services he is entitled to a reasonable compensation, but, because of the uncertainty of the market, deserving profits may be replaced by a net loss.

If growers cooperate with shippers by preparing their cowpeas properly for the market as already outlined, and do not rush them on the market too early in the season or at a time when the demand is poor, shippers can operate on a much lower margin with safety and pay a correspondingly higher price to growers. Delivery to local shippers should be made in as large lots as possible. The surplus cowpeas of the average farm can be delivered in a single trip with a team. It usually is time lost on the part of the grower to market cowpeas in "installments" when one trip and one transaction would complete the job. Also, it costs shippers practically as much to receive, weigh, pay for, and record a 1-bag lot as it does a 10-bag or larger lot.

There usually is keen competition between local shippers at the various shipping points which tends to insure growers a reasonable price for cowpeas. It frequently happens, however, that shippers are not thoroughly familiar with the principal producing and consuming areas, wholesale distributing points, varietal preferences, and various other price-affecting factors. Growers, as well as shippers, may inform themselves through reports issued by the Department of Agriculture regarding these fundamentals and regarding prospective production, prices, and movement of the new crop, and thus be able to determine whether prices offered by local shippers are in line with those prevailing elsewhere.

SELLING TO DISTANT SEEDSMEN.

If there is no local demand, either from farmers or local shippers, for the surplus production of cowpeas, or if the local market is unsatisfactory for any reason, growers should endeavor to find a market elsewhere. The first probable outlet to be considered is through seedsmen and dealers in large distributing centers.

When contemplating selling to such seedsmen and dealers a grower should first take inventory of his stocks of cowpeas by varieties, and if he does not have a minimum carload (24,000 to 30,000 pounds), ascertain whether he might make up this quantity with his neighbors. He should then draw a small representative sample of each variety, submit it to several seedsmen who are probably in the market, stating the quantity of each variety offered, and ask for quotations f. o. b. grower's shipping point. Each sample drawn should contain at least 4 ounces and be numbered or marked to identify it with the lot from which it was drawn. It should be divided and half of it retained by the grower for use in case of a possible dispute as to the quality of the cowpeas shipped.

If one of the offers received is accepted by the grower he should wire acceptance immediately, confirming it by letter. Shipment should be made promptly or at any time specified in terms of sale. The quality of stocks shipped should compare favorably with that of the samples submitted and the shipment should be made up of varieties and quantities as sold. It is necessary that a careful check be made of the weights by varieties, and to facilitate this it is desirable that the bags be of 100 pounds net capacity and that they be tagged or stenciled with the variety of cowpeas contained. Shipments of cowpeas usually are made on terms of bill of lading attached to sight draft for 60 to 80 per cent of the amount of the invoice, the balance to be paid upon arrival and acceptance of the goods, or on terms of arrival draft for the full amount.

SELLING THROUGH FARM-PAPER ADVERTISING.

Farm-paper advertising is the agency through which growers may receive, on the average, the largest gross return for cowpeas. But, on the other hand, the net returns may be less than might be received through any of the other agencies already mentioned. There are instances, however, where this method of disposing of surplus cowpeas seems to be most effective. If there is no local farm demand, if there is no local shipper, or if the only one is unbusinesslike in his methods and fails to render the services demanded by his position, and if satisfactory contact can not be established with a distant seedsman, then the most practical outlet remaining is through farm paper, or possibly weekly and daily newspaper, advertising. If all of these agencies are available to a grower it becomes a local problem as to which he should use. His one guide in choosing the agency for his needs should be to choose the one which will return him the largest net amount for his product.

The purpose of an advertisement is to bring the seller into contact with prospective buyers. It should be so worded as to describe briefly and yet clearly the product for sale. The selling price should be included, so that the advertisement will contain all of the information that a buyer should have and he can place an order without making further inquiry. Suggested forms of advertisements are shown below:

> *Cowpeas, Recleaned.*—Sacked in new bags; 900 pounds Whips, $4 per 100 pounds; 600 pounds Brabhams, $4.50 per 100 pounds.
>
> A GROWER, *Anytown, U. S.*
>
> *Cowpeas for Sale.*—1,200 pounds Clays, slightly mixed with Whips, $3.90 per 100 pounds. Sample submitted if desired.
>
> ________ [Name.] ________ [Post office.] ________ [State.]
>
> *Cowpeas.*—1,500 pounds sound, recleaned Brabhams, mixed with 15 per cent Irons, $4.25 per 100 pounds, f. o. b.
>
> INGLESIDE FARM, *Mayville, N. C.*

The cost of running an advertisement in the classified columns of most farm papers ranges from 5 cents to 15 cents a word for each issue, varying largely with the circulation of the various papers. At the low rate, a 30-word advertisement may be run three consecutive issues at a total cost of $4.50. Sales of only 1,500 pounds from such an advertisement would distribute the advertising cost to 30 cents per 100 pounds. An advertisement does not always bring the desired results from a single insertion and it may be necessary to repeat it several times, thus increasing the cost per unit of quantity sold. Most papers require that cash accompany all orders for advertising.

It seems advisable that growers having only a few hundred pounds of cowpeas to sell, defer advertising until the early spring months. The person reached by farm-paper advertising is the farmer. Farmers do not often anticipate their needs for cowpeas early in the season and are more receptive to offers placed before them nearer the spring planting season.

Orders for cowpeas usually are accompanied by cash, and shipment should be made promptly. All inquiries received should have prompt attention whether they are accompanied by an order or not. Any orders sent in after the supply is sold out should be acknowledged and if money is inclosed it should be returned at once. Reputation for promptness in handling all of the details connected with selling by mail order is a valuable asset. Care should be taken to fill all orders with the stipulated variety and quantity. The cowpeas shipped should be of high quality or just as represented in advertisements, letters, or by samples.

In selling cowpeas direct to other farmers through farm-paper advertising, or through any other medium when delivery is made by a common carrier, growers come into contact with the requirements of the State seed laws. Most of the States have laws which require that seeds, including cowpeas, when sold within the State must bear a label or tag showing all or a part of the following information: Pure seed, percentage; inert matter, percentage; foreign seed, percentage; noxious weed seed, names and number or percentage; germination, percentage, together with date of test; locality where, and the year when, grown. The kind of seed and the name and address of seller must be given. Information regarding the provisions of any of the State seed laws as affecting cowpeas may be obtained from the State departments of agriculture or the State agricultural experiment stations.[7]

Selling cowpeas through farm-paper advertising entails much work which the average grower may not have the time or inclination to do. To attempt to use this method before giving careful consideration to the advantages of local agencies and the disadvantages and expense of the mail-order method might prove a costly venture. On the other hand, a farm-paper advertisement often is the only accessible source of supply for a farmer who desires to purchase cowpeas for seed. He may be in a section where cowpeas are not generally grown and where no seed is available either from local growers or dealers. But through the medium of an advertisement inserted in his farm paper by a grower located in a distant producing section he may be able to obtain the cowpeas desired.

THE SELLING PRICE OF COWPEAS.

The selling price of cowpeas varies with the commercial supply, the quality of the crop for seed, the variety, and the nearness to planting date. When the crop begins to move during November no one seems to know what price should be paid. Prices offered both by local shippers and dealers in wholesale distributing markets at that time usually are lower than the price obtained for the bulk of the crop later in the season. To buy cowpeas before the price level has been reached and to store them, pending the opening of the spring demand, constitute risky speculation, and shippers and dealers can not be expected to assume the risk on a narrow margin of profit. The grower, however, may well carry the cowpeas until a market is established. With the commercial supply being carried for two or three months by several thousand growers, the individual risk is reduced to a minimum.

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[7] At this time (January, 1923), all States have seed laws *except* the following: Alabama, Connecticut, Florida, Georgia, Kansas, Massachusetts, Mississippi, Nevada, and Rhode Island.

SEASONAL TREND OF PRICES.

The price paid growers for cowpeas is almost invariably higher as the planting season approaches. This is because stocks are moving more freely from growers' hands through the various channels of distribution to farmers in consuming sections. By storing cowpeas on the farm temporarily until other farmers are ready to buy, growers may perform a service for which they will be well paid. This is shown clearly in Table 7, which gives the average prices over a period of years paid to growers on the 15th of each month from the time the new crop begins to move from growers' hands in October until the movement is over in June of the following year. Although the price paid for any year's crop may not advance materially as the season progresses, the table shows that there is little if any decline. On the other hand, the price paid for the 1916 crop advanced over 100 per cent from October 15 to June 15, the 1917 crop advanced 37 per cent from October 15 to March 15, the 1918 crop advanced 50 per cent from November 15 to June 15, and the 1919 crop advanced 86 per cent from October 15 to May 15.

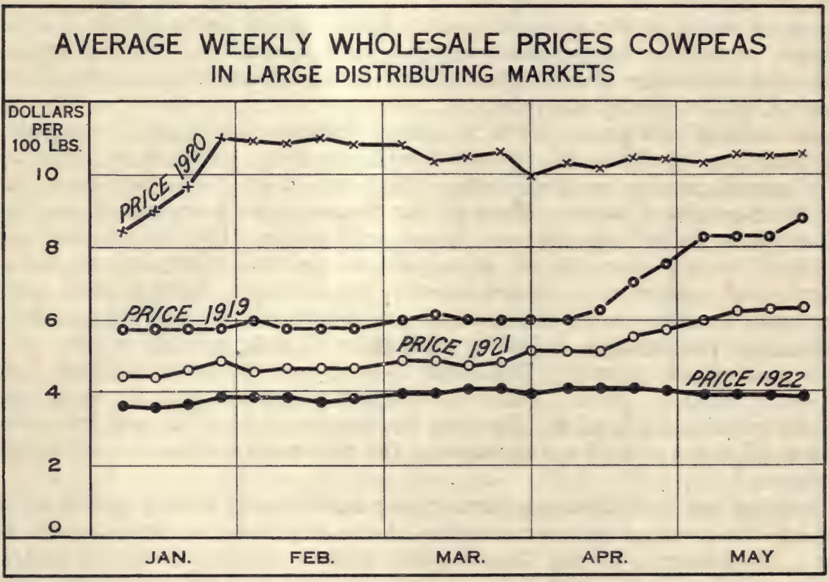

FIG. 7.—Chart showing the average weekly wholesale selling prices of cowpeas at important markets, 1919–1922.

TABLE 7.—*Average prices paid growers for cowpeas in the United States (per 100 pounds).*

Month.	1915 crop.	1916 crop.	1917 crop.	1918 crop.	1919 crop.	1920 crop.	1921 crop.
	1915	*1916*	*1917*	*1918*	*1919*	*1920*	*1921*
Oct. 15	$2.60	$2.50	$3.65	$3.90	$4.35	$4.60	$3.35
Nov. 15	2.50	2.65	3.75	3.85	4.50	4.10	3.10
Dec. 15	2.50	2.90	4.00	4.00	4.65	3.85	2.95
	1916	*1917*	*1918*	*1919*	*1920*	*1921*	*1922*
Jan. 15	2.60	3.15	4.35	4.00	5.25	3.25	2.85
Feb. 15	2.60	3.50	4.85	4.15	6.15	3.40	3.00
Mar. 15	2.60	3.85	5.00	4.15	6.60	3.40	3.10
Apr. 15	2.50	4.25	4.90	4.50	7.00	3.60	3.10
May 15	2.50	4.90	4.75	4.85	8.10	4.10	3.15
June 15	2.35	5.15	4.25	5.75	8.10	4.40	3.05

The trend of wholesale selling prices is upward as the planting season approaches. This fact is illustrated in Figure 7, which shows in graphic form the average weekly wholesale selling price of cowpeas during the main selling season for the years 1919 to 1922, inclusive. The upward trend at each of six wholesale markets, Baltimore, Richmond, Louisville, Chicago, St. Louis, and Kansas City, Mo., for the years 1920 to 1922, inclusive, is given in Table 8.

TABLE 8.—*Weekly average wholesale selling price of cowpeas (per 100 pounds).*

Date.	Baltimore.	Richmond.	Louisville.	Chicago.	St. Louis.	Kansas City.
1920.						
Jan. 3	$6.00	$7.75	$10.00	$9.50	....	$10.00
10	7.00	7.75	10.00	7.50	....	9.75
17	7.00	8.00	10.00	7.50	....	10.50
24	7.00	9.00	11.00	8.00	....	12.50
31	9.00	10.00	11.00	8.50	$14.00	12.50
Feb. 7	9.00	10.00	11.00	9.00	13.00	12.50
14	9.00	10.00	11.00	9.50	13.00	12.00
21	9.00	10.00	11.00	9.50	12.50	12.00
28	9.00	10.00	10.00	10.00	12.50	12.00
Mar. 6	9.00	10.00	10.00	10.00	12.50	12.00
13	9.00	9.75	10.00	10.00	11.00	11.50
20	9.00	9.75	10.00	10.00	11.00	11.50
27	9.00	9.75	10.00	10.00	10.50	11.50
Apr. 3	9.00	9.00	10.00	10.00	10.50	11.00
10	9.00	9.00	10.00	10.00	10.50	11.00
17	9.00	9.00	10.00	10.00	10.50	10.50
24	9.00	10.00	10.00	10.50	11.00	10.50
May 1	9.00	10.00	10.00	10.50	11.00	10.50
8	9.00	10.15	10.50	10.50	11.00	11.00
15	10.00	10.25	10.50	10.50	11.00	11.00
22	10.00	10.25	10.50	10.50	11.00	11.00
29	10.00	10.25	10.50	10.50	11.00	11.00
1921.						
Jan. 8	4.50	5.00	4.50	4.00	4.00	....
15	4.50	5.00	4.50	4.00	4.00	....
22	4.50	5.00	4.85	4.60	4.00	....
29	4.50	5.25	4.50	6.00	4.00	....
Feb. 5	4.50	5.25	4.50	4.75	4.00	4.25
12	4.50	5.25	4.50	4.75	4.25	4.50
19	4.50	5.25	4.50	4.75	4.25	4.50
26	4.50	4.80	5.00	4.75	4.25	4.75
Mar. 5	4.50	4.80	6.00	4.50	4.35	5.00
12	4.50	4.80	6.00	4.50	4.35	5.00
19	4.50	4.80	5.00	4.50	4.50	5.00
26	4.50	4.80	5.00	4.50	4.50	5.00
Apr. 2	5.00	5.00	5.00	5.40	4.75	5.00
9	5.00	5.00	5.00	5.40	4.75	5.00
16	5.00	5.00	5.00	5.40	4.75	5.00
23	5.75	5.60	6.00	6.00	4.90	4.75
30	5.75	6.00	5.50	6.00	6.00	4.75
May 7	6.00	6.25	5.50	6.00	6.65	5.75
14	6.00	6.35	6.60	6.00	6.35	5.75
21	6.25	6.50	6.50	6.00	6.45	5.75
28	6.50	6.65	6.50	6.00	6.50	5.75

TABLE 8.—*Weekly average wholesale selling price of cowpeas (per 100 pounds)*—Contd.

Date.	Baltimore.	Richmond.	Louisville.	Chicago.	St. Louis.	Kansas City.
1922.						
Jan. 1	$3.50	$4.50	$3.60	$3.00	$3.35	$3.75
7	3.50	4.50	3.60	3.00	3.35	3.75
14	3.50	4.50	3.75	3.00	3.00	3.75
21	4.00	4.50	3.75	3.00	3.00	3.75
28	4.00	4.50	4.00	3.50	3.35	3.75
Feb. 4	4.00	4.40	4.00	3.50	3.50	3.75
11	4.00	4.40	4.00	3.50	3.50	3.75
18	4.00	4.40	4.00	3.50	2.50	3.75
25	4.00	4.40	4.00	3.50	3.00	3.75
Mar. 4	4.00	4.40	4.00	3.50	3.50	3.75
11	4.00	4.40	4.00	3.50	3.50	3.75
18	4.00	4.40	4.00	3.50	3.75	4.00
25	4.00	4.40	4.00	3.50	3.75	4.25
Apr. 1	4.00	4.00	4.00	4.00	3.75	4.00
8	4.00	4.40	4.00	4.00	3.75	4.00
15	4.00	4.40	4.00	4.00	3.75	4.00
22	4.00	4.40	4.00	4.00	3.75	4.50
29	4.00	4.25	4.00	4.00	3.75	4.50
May 6	4.00	4.00	4.00	4.00	3.75	4.50
13	4.00	4.00	4.00	4.00	3.75	4.50
20	4.00	4.00	4.00	....	3.75	4.50
27	3.90	4.00	4.00	....	3.75	4.25

It will be noted that there may be some variation between the prices at two or more markets on the same date. But with very few exceptions there is the same general upward trend at all markets. These tables and the chart are further evidence of the possibilities of a better price to the grower who delays marketing his cowpeas until the consumer is ready to purchase.

PRICE VARIATIONS IN DIFFERENT SECTIONS.

There is considerable variation between the prices received by growers in different producing sections. The average price received by growers for the crops of 1917 to 1921, inclusive, is shown by States or districts in Table 9.

TABLE 9.—*Average price paid to growers for cowpeas for crops 1917–1921 (per 100 pounds).*

State or district.	1917 crop.	1918 crop.	1919 crop.	1920 crop.	1921 crop.
Northern Alabama	$3.60	$4.05	$6.25	$2.90	$2.45
Southeastern Alabama	3.50	3.85	6.65	2.40	2.45
Southwestern Alabama	3.40	3.50	5.25	2.40	2.50
Arkansas	5.00	3.60	6.65	3.00	2.40
Delaware	4.40	4.60	6.15	4.10	3.65
Northern Georgia	3.65	3.55	5.25	2.95	2.55
Southeastern Georgia	4.35	4.00	6.15	3.00	2.50
Southwestern Georgia	3.95	3.90	6.60	2.65	2.45
Illinois	3.75	5.00	6.10	2.75	2.10
Indiana	4.30	4.00	5.35	3.05	2.45
Louisiana	4.15	3.40	7.00	3.00	2.40
Northern Mississippi	3.75	3.75	5.95	2.75	2.55
Southeastern Mississippi	3.85	4.90	6.05	2.75	2.70
Southwestern Mississippi	4.40	3.60	5.25	2.60	3.15
Missouri	3.35	3.50	5.90	2.60	2.40
Eastern North Carolina	5.15	4.25	6.55	4.00	3.90
Central North Carolina	5.10	3.50	5.25	3.70	3.50
Western North Carolina	4.15	3.80	5.75	3.45	3.80
Northeastern South Carolina	4.55	3.45	5.95	2.95	3.00
Southeastern South Carolina	4.15	3.80	5.55	2.90	2.95
Western South Carolina	4.15	3.90	5.70	2.65	2.95
Eastern Tennessee	4.30	3.65	5.85	2.95	2.55
Central Tennessee	4.55	4.40	6.00	2.95	2.55
Western Tennessee	3.80	4.85	6.90	2.60	2.60
Texas	4.05	3.65	6.00	3.00	2.40
Other States	4.90	4.40	6.25	3.00	2.10

The variation in prices as shown is largely the result of the speculative nature of all offers for the crop, especially that portion which growers attempt to market early in the season. The tendency is for the price in various sections to become more nearly uniform as the selling season progresses.

RELATION OF VARIETY TO PRICE.

The variety is an important factor in determining the price. Some varieties sell at a premium of 25 to 50 per cent over the lowest-priced variety. Growers should recognize this fact and should preserve the identity of their cowpeas by varieties and market them by variety name. The variation in the selling prices of the different varieties is forcefully illustrated in the following reproduction of a number of advertisements as they appeared in farm papers:

Cow Peas

Brabham, Irons	$2.50
Clays, New Eras	$2.25
Whips, Mixed	$2.00

Sound stock, new bags, prompt shipment.

Peas, late Whips	2.25 bu.
Peas, early Whips	2.25 bu.
Mixed Peas	2.00 bu.
Iron Peas	2.50 bu.
Brabham Peas	3.00 bu.

F. O. B. check with order.

Cow Peas

Mixed Clays and Straight Whips $2.15. Straight Clays and Mixed Unknowns $2.25. Brabhams and Irons $2.35.

FEW HUNDRED BUSHELS Brabham Peas, $2.50 bushel; Whippoorwills, $2.25; 15 bushels mixed, $2.20.

Straight Iron Peas	2.50 per bu.
Straight Brabhams	2.75 per bu.
Bunch Speckle	2.25 per bu.
Mixed	2.00 per bu.

All F. O. B. here.

The same variation in prices of varieties occurs in quotations by wholesale seedsmen as illustrated in the following extracts from dealers' price lists:

Cow Peas

2-bu. Sacks Included
Split Packages, 6¢ Extra.

	Per bu.
New Era	2.50
Brown Whippoorwill	2.40
Grey Crowder	2.70
Blacks	2.85
Mixed	2.30
Black Eyes (Imp.)	1.90

Cow Peas

RECLEANED, SACKS FREE

	Per Bu.
Mixed	2.30
Brown Whippoorwill	2.40
Gray Whippoorwill	
Blacks	2.65
New Era	
Brabham	2.50
Clay	2.50

SACKS INCLUDED, 2½ BU. TO SACK

	Price per 100 lbs.	Per Bu.
Brabham	$4. 17	$2. 50
Whippoorwill—Brown	4. 09	2. 45
Whippoorwill—Gray		
Black Eye Imported 77% G	3. 33	2. 00
Black Eye Virginia	4. 58	2. 75
Gray Crowder or Whipp		
Clay	4. 25	2. 55
Groit	4. 33	2. 60
New Era	4. 08	2. 45
Mixed	3. 92	2. 35

PEAS

ALL RECLEANED, EVEN WEIGHT SACKS

	5 bu. @	25 bu. @
Small Virginia Black Eye	2. 55	2. 50
Large Virginia Black Eye	3. 00	2. 95
Jumbo Black Eye	3. 25	3. 20
Whippoorwill	2. 55	2. 50
New Era	2. 55	2. 50
Brabham	2. 80	2. 75
Groit	2. 80	2. 75
Mixed	2. 50	2. 45
Black	2. 85	2. 80

RECLEANED STOCKS. SACKS FREE

	5-bu. lots, per bu.	Per bu.
Mixed Cow Peas and Soja Beans	2. 65	$2. 75
Mixed Cow Peas	2. 75	2. 85
New Era Peas	2. 90	3. 00
Whippoorwill Peas	2. 90	3. 00
Red Ripper Peas	2. 90	3. 00
Clay Peas	2. 90	3. 00
Wonderful Peas	2. 90	3. 00
Iron Peas	3. 15	3. 25
Brabham Peas	3. 15	3. 25
Taylor Peas	3. 15	3. 25
Groit Peas	3. 15	3. 25
Black Peas	....	3. 25

The Whippoorwill is the basis for variety values, the price of most other varieties ranging upward. In general, Brabhams seem to command the highest price, followed closely by Irons, while mixed varieties invariably are sold at the heaviest discount. New Eras do not vary greatly from the basic price, sometimes being slightly higher or lower.

It should not be concluded that because a variety is higher in price it is necessarily more expensive for planting purposes. The New Era and Iron varieties, for example, are smaller than Whippoorwills and Clays and have a proportionately greater planting capacity per unit of weight. For this reason, other factors being equal, the smaller seeded varieties even at a higher price may be more economical for the farmer to buy for planting purposes. The estimated number of cowpeas per pound by varieties and the relative planting capacity of each are given in Table 10.

TABLE 10.—*Number of cowpeas per pound and comparative planting capacity by varieties.*

Variety.	Number.	Planting capacity compared with Whippoorwills.	Variety.	Number.	Planting capacity compared with Whippoorwills.
Brabham	5,188	172	Unknown	2,864	95
New Era	4,448	147	Red Ripper	2,427	80
Iron	3,840	127	Black	2,394	79
Groit	3,227	107	Blackeye (large)	2,260	75
Whippoorwill	3,015	100	Taylor	1,819	60
Clay	2,890	96			

DISCOUNT FOR MIXED VARIETIES.

One of the chief causes of low average farm prices for cowpeas is the production and marketing of "mixed" varieties. It was shown in Table 2 that 25 per cent of the cowpeas entering commercial channels is mixed. The average price received by growers for mixed varieties is 10 to 25 per cent less than that received for straight varieties. On the basis of a market value of $4 per 100 pounds for straight varieties, the direct loss to growers on this portion of their crop is 40 cents to $1 per 100 pounds.

This unfavorable condition is one of the easiest to correct. Much of the mixed stock that appears on the market is occasioned by indifference to the varietal purity of seed stocks. Only pure seed of known varieties should be planted if it is intended to market the seed crop. The varieties of cowpeas are described in detail in a bulletin [8] issued by the United States Department of Agriculture.

Cowpeas also become mixed in harvesting and thrashing. This can be prevented by the exercise of ordinary care in keeping each variety separate during the entire process of harvesting and thrashing, whether by hand or machinery.

The exact meaning of the term "mixed" as applied to cowpeas is sometimes misunderstood by growers. Instances are known where growers have sold to local shippers a lot of cowpeas as "mixed" when in reality it consisted of one or more bags each of several varieties. For example, the lot may consist of 900 pounds total, made up of 200 pounds Whippoorwills, 300 pounds Brabhams, 300 pounds Clays, and 100 pounds Irons, each variety in separate bags. To sell such a lot of cowpeas on the basis of the discount price of "mixed" is shortsighted to say the least. It not only means a loss to the grower but affords an opportunity for local shippers to reap an unearned profit by keeping each variety separate, accumulating larger quantities of each, and selling on the basis of straight variety values. Only when two or more varieties of cowpeas are contained in the same bag and their identity lost should they be classed as mixed and sold at the prevailing discount.

Just what percentage of other varieties should be permitted in a given variety before it is classed as "mixed" has not been determined. This is a question of grades and standards. The discount in price, however, usually is not graduated according to the percentage of other varieties present. Ten per cent of other varieties present, for example, may force cowpeas into the "mixed" class and reduce the price to the same low level of a 50-50 mixture.

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[8] Morse, W. J.: Cowpeas; Culture and Varieties. U. S. Department of Agriculture, Farmers' Bulletin No. 1148, 1920.

This is not as it should be because Whipporwills containing only 10 per cent of other varieties, for example, are greater in value, on the basis of the present relation of varieties, than Whippoorwills containing a larger percentage of other varieties and should sell for less than Brabhams containing only 10 per cent of other varieties.

Inasmuch as cowpeas are sold on the basis of sample and description and not by grade, it should not be difficult to arrive at a fair price for mixtures. Growers offering cowpeas for sale, however, should be accurate and brief in their descriptions. A study of a few samples should assist growers in this matter. By taking a sample containing 100 cowpeas and counting the number of each variety present the result will indicate automatically the percentage of each variety. If, for example, a 100-seed sample is composed of 75 Whippoorwills, 10 Clays, 8 Red Rippers, and 7 Blacks the proper description is "Whippoorwills containing 25 per cent of other varieties."

The discount for mixed cowpeas should be figured on the basis of the prevailing price of straight or unmixed cowpeas of the variety predominating in the mixture. For example, if the prevailing discount for mixed cowpeas is 10 per cent and straight Brabhams are selling at $4 per 100 pounds, the price of mixed Brabhams should be 10 per cent less or $3.60. However, with straight Brabhams selling at $4, straight New Eras, for example, would be quoted at about $3.50, on the basis of the present relation of variety values, and the price of mixed New Eras would be reduced 10 per cent or to $3.15. In other words, there should be the same range between the price of mixtures containing 50 per cent or more of any one variety as between the price of straight varieties.

COMPETITIVE CROPS.

The price of cowpeas is affected more or less by the supply of soy beans and velvet beans for seed and the publicity given these crops by various agencies. Substitution among these three crops is not general, however, and the demand for cowpeas remains more nearly constant while the price of any one or two which may be in short supply is curbed by the relatively lower price of the crop of which the seed supply is greatest.

Based on the comparative seeding capacity of each of these crops per unit, the price of cowpeas is almost invariably higher than that of either soy beans or velvet beans, but the fact that cowpeas succeed under a greater diversity of conditions makes them more desirable in many sections.

Although the acreage and consequent demand for soy beans and velvet beans for seed have increased greatly during recent years, they have had little effect on the demand for cowpeas. On the other hand, the total production of cowpeas for seed shows little change and if the supply is to keep pace with the demands of diversified farming the seed crop must of necessity be conserved, prepared properly, and the surplus distributed equitably to farmers in consuming sections. This is the growers' opportunity and the profit received for this minor cash crop will be in direct proportion to the quality of the cowpeas produced, the preparation given them for market, and the judicious selection of the time of marketing and the agency through which they are sold.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1309

CONTROL *of the* COMMON MEALYBUG *on* CITRUS *in* CALIFORNIA

THE COMMON MEALYBUG is one of the more important citrus insect pests of California and in severe infestations causes serious damage to the foliage and fruit. It attacks all varieties of citrus, though the navel and Valencia oranges, grapefruit, and lemon are most seriously damaged. Heavy defoliation, fruit dropping, and a poor grade of fruit frequently result from the attack of this insect pest.

The control methods outlined in this bulletin include control by natural enemies and by spraying. The Argentine ant, where present, is an important hindrance to control, and attention must be given to it.

When the insect enemies of the mealybug are not present in sufficient numbers, the liberation of certain predators is recommended.

This bulletin supersedes Farmers' Bulletin 862, The Common Mealybug and Its Control in California.

Washington, D. C. February, 1923

CONTROL OF THE COMMON MEALYBUG[1] ON CITRUS IN CALIFORNIA.

ARTHUR D. BORDEN,[2]
Assistant Entomologist, Fruit Insect Investigations, Bureau of Entomology.

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INTRODUCTION.

FOR many years the common or "citrus" mealybug has been a menace to the citrus grower of California, and of necessity a great amount of attention has been paid to its control. At first, only occasional outbreaks were noted in widely separated localities, but in recent years the infestations have become more general and have extended over much wider territories.

These infestations, when severe, very seriously affect the appearance of an orchard and frequently cause a heavy loss in the fruit crop. Fortunately, however, this pest is frequently held down by its natural enemies and weather conditions to such an extent as to prevent serious damage.

In districts infested with the Argentine ant the mealybug has been noted to become much more severe and difficult to control. This is due to the relation this ant has to the natural enemies of the mealybug and to the pest itself. The ant now has a very wide distribution throughout citrus districts in the United States, which necessitates closer attention to its control.

The citrus grower can ill afford to permit the mealybug to become prevalent in his grove, especially when the ant is present, as even in a light infestation the loss in a season's crop will amount to much more than the cost of control.

DISTRIBUTION.

The common mealybug is of world-wide distribution and occurs on a large list of host plants. It has been reported as a citrus pest for more than 30 years in California, and frequently its control has been of serious concern. It is now reported from Ventura, Los Angeles, San Diego, Orange, and Santa Barbara Counties, where frequently, under favorable conditions, it becomes a serious pest.

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[1] *Pseudococcus citri* Risso.
[2] Resigned December 5, 1921.

The chief means of distribution of the pest is apparently through infested nursery stock, picking boxes, picking ladders and sacks, and the pickers' clothing, and by birds and insects. Picking boxes which have been used to transport infested fruit should be thoroughly treated before use in an uninfested orchard.

In many localities within the counties mentioned the infestations have been so completely eradicated by the methods given in this bulletin that the common mealybug is no longer reported as a pest in the citrus orchards.

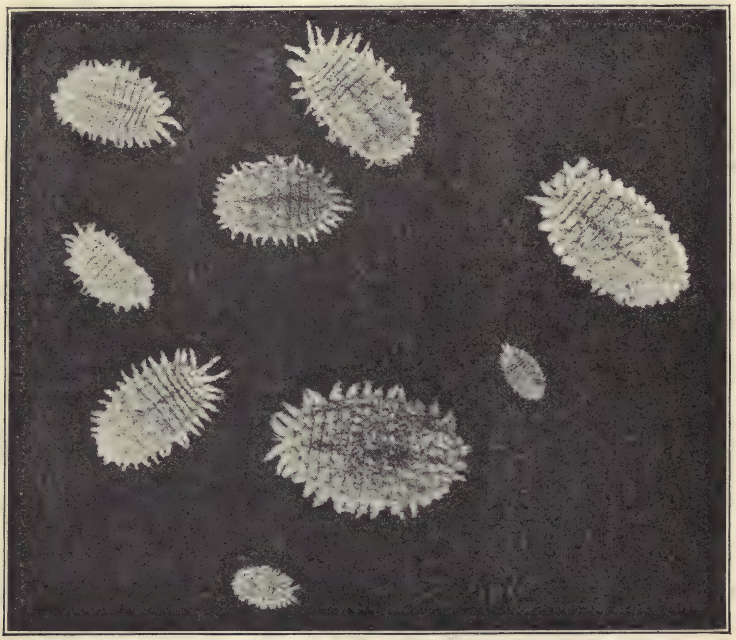

FIG. 1.—A group of common mealybugs. Enlarged about 9 times. (Woglum and Neuls.)

NATURE OF INJURY.

The common mealybug attacks the fruit, foliage, and twigs of citrus trees. Its feeding on the rind of the mature fruit causes serious discoloration and pitting, and its attack on the young fruit, especially under the sepals, materially weakens it and causes it to drop prematurely. The attack on the foliage and twigs may very greatly lower the vitality of the tree and even cause a severe defoliation.

In the honeydew secreted by this insect grows a black fungus, which is commonly termed "smut" or sooty mold, and the deposit of this on the fruit and foliage gives the tree a very unsightly appearance. Fruit covered with this sooty mold has to be washed in the packing house, which adds to the cost of handling.

In heavy infestations not only may severe defoliation occur, but a large percentage of the fruit may be lost by premature dropping. The loss in grade of the fruit is also very decided, and much of it may even be classed as "culls."

HOST PLANTS.

The common mealybug attacks all varieties of citrus, though the navel and Valencia oranges, grapefruit, and lemon are most seriously damaged. It possibly develops more readily on the lemon and grapefruit, though infestations on the oranges may be equally heavy. Its habit of collecting in the navel end of the orange makes it very difficult to dislodge. It also frequently gathers where two fruits touch, or in clusters of fruit, and forms large masses. During the reproduction periods large clusters of mature females with egg sacs may form on the fruit, limbs, or roughened places in the trunk. Fruit thus attacked is seriously discolored.

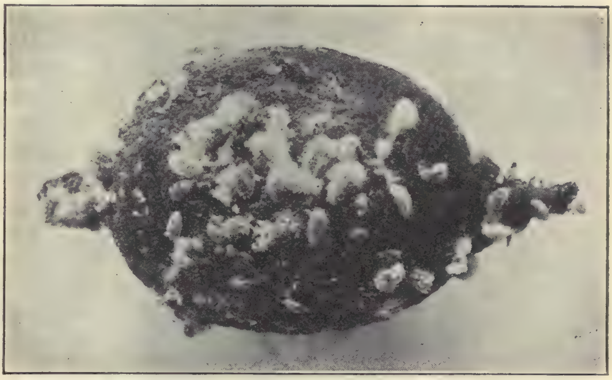

FIG. 2.—Lemon infested with the common mealybug. (Woglum and Neuls.)

CHARACTERISTICS AND LIFE HISTORY.

The general appearance of the maturing female is shown in Figure 1 and the infestation in Figure 2. The body of the female is covered with a white waxy secretion and the edge of the body is fringed with short waxy filaments. The adult female is similar in appearance to the immature form except in size and in the amount of waxy covering. The eggs are deposited in a white cottony mass secreted behind the mature female. The number of eggs deposited depends upon the size of the adult female and may range from 300 to 600 per individual. The length of a generation is from about seven weeks in summer to six months in winter, and there may be three or more generations in a year.

The immature male is similar to the immature female in the early stages, but in about four weeks forms a cocoon, and from this about two weeks later emerges a very small and delicate, winged gnatlike adult male. The life of the male is short.

The generations usually overlap so greatly during the winter months that they are difficult to distinguish, but with the warm weather of early summer a maximum infestation appears which may carry over well into the autumn. The seasonal history of the mealybug is difficult to follow on account of the overlapping of generations and the uneven development.

RELATION TO THE ARGENTINE ANT.

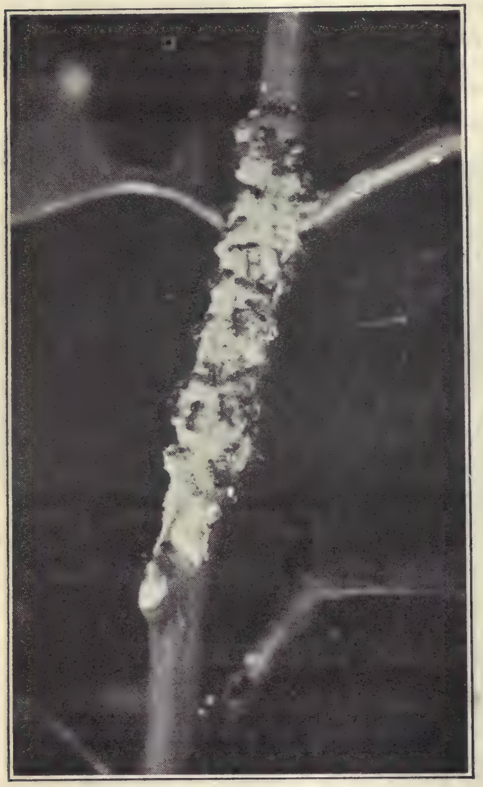

FIG. 3.—Ants attending a group of mealybugs. Their almost constant presence protects the mealybug from its natural enemies. (Woglum and Neuls.)

In the investigations of the Bureau of Entomology it has been found that the Argentine ant is a very important hindrance in the control of the citrus mealybug. The constant attendance of the ant (fig. 3) protects the mealybug from its natural enemies and results in its abnormal and often rapid increase. It has been definitely proved that the ant not only distributes the mealybug but also destroys the eggs and larvæ of certain natural enemies and by its constant attendance prevents the normal egg laying and feeding of the adult parasites and predatory enemies.

Remarkable results have been obtained in many citrus orchards by controlling the Argentine ant, thus permitting the natural enemies to breed freely. In fact, it is almost imperative, in order to obtain even commercial control of the mealybug, that the ant be eliminated or brought under control.

Ant-control methods.—The control of the Argentine ant has been carefully worked out and may be accomplished at a small cost. The method consists of distributing throughout the ant-infested area a poisoned sirup in a suitable container. This sirup is prepared from the following formula, preferably by a competent druggist, though it may be prepared at home provided clean equipment, accurate weighing, and proper materials are employed.

Formula and method of preparing ant sirup.

	Cost.
Water (11 pints)	$0.000
Tartaric acid (crystallized) (7 grams)	.016
Benzoate of soda (9 grams)	.029
Granulated sugar (12 pounds)	.84
Honey, strained (2 pounds)	.32
Sodium arsenite, C. P. (¾ ounce)	.047

Total sirup 2½ gallons, costing about 50 cents a gallon.

Put 10 pints of water in a clean vessel over a low fire. When tepid, add tartaric acid, then benzoate of soda, and then the sugar, slowly, while stirring to prevent burning. Measure the depth of the liquid with a stick. Slowly bring it to a boil and allow it to simmer for from 30 to 40 minutes. Remove from the stove and add water to compensate for evaporation. Stir in the honey before the mixture cools. Then add sodium arsenite which has been dissolved in 1 pint of hot water and partially cooled before being poured into the sirup. Stir thoroughly.

It is necessary that great care be used in the selection of the materials as well as in the preparation of the sirup. The sodium arsenite should be chemically pure. The honey should be strained and free from comb. The sodium arsenite preferably should be dissolved in distilled water to avoid the precipitation which sometimes occurs if very hard water is used. Vessels should be thoroughly cleaned before being used for the preparation of ant sirup, and it is desirable that they be used for this purpose only. The stability of the sirup depends very much upon the way it is boiled. If brought to a boil within a few minutes and boiled vigorously for 30 minutes, the stability appears to be much less than if brought to a boil very slowly and then merely allowed to simmer for 30 or 40 minutes. Where several times the amount given in the formula is made in a large vessel, the sirup appears to "stand up" best. This seems to be due to the fact that the sirup does not come to a boil for an hour or longer, which probably results in greater inversion. The sirup should be used when fresh. Clean glass bottles are best if the sirup is to be stored.

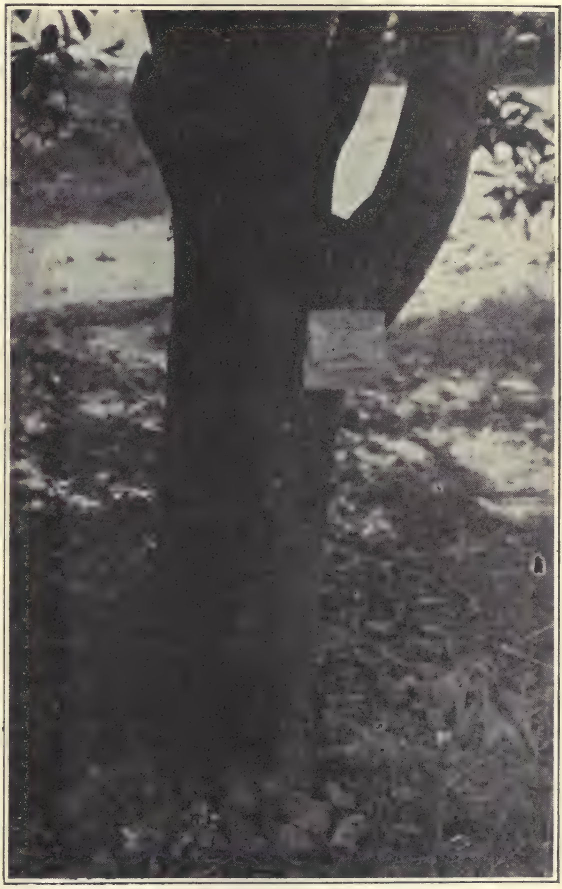

FIG. 4.—A paraffined paper bag in place on tree. (Woglum and Neuls.)

The types of containers which have been successfully employed in applying the sirup include a quarter-pound paraffined paper bag (fig. 4), a 4-ounce paraffined spice can (fig. 5), and a 4-ounce paraffined pressed drinking cup. The paraffined spice can has proved most desirable, as it does not collect water and may be used over and over if properly cleaned and refilled. The paraffined bags and cups are inexpensive, and if they do not leak are satisfactory after the rainy season or where water is not likely to reach them. Only paraffin having a high melting point (above 124° F.) should be employed in paraffining the cans or bags. Properly prepared for distribution, the approximate cost of the paraffined spice cans is 5 cents each; of the paraffined quarter-pound bags, 3 cents; and of the paraffined drinking cups, 1 cent.

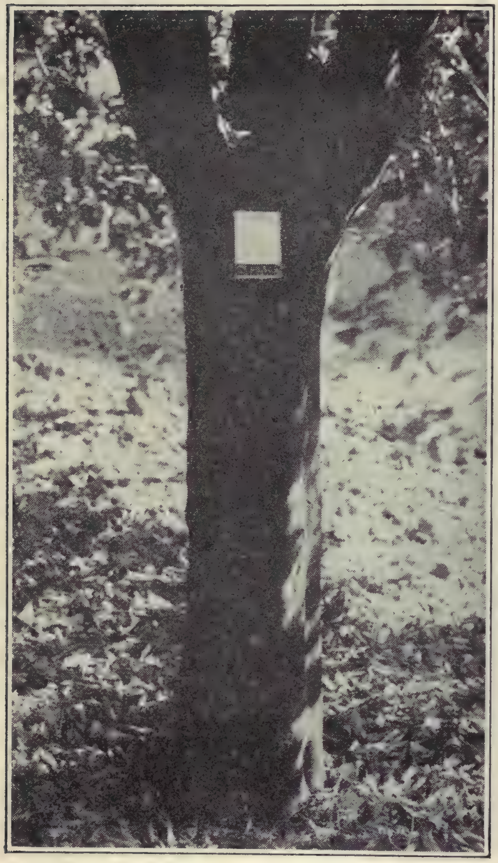

FIG. 5.—A paraffined spice can on tree trunk. (Woglum and Neuls.)

In each container about 1½ liquid ounces of sirup is used. Four or five clean strands of excelsior about a foot long may be suspended very loosely from the top of the container (to serve as an attractive runway for the ants after entering) and the lid of the can replaced or the top of the bag folded over. The cans have a small hole (not over ¼ inch in diameter) punched near the top of one side before they are paraffined, and by this means each can is hung on a fourpenny finishing nail driven into the tree about a foot and a half from the ground over the ant trail. The ants travel up the trunk, out along the nail, and into the can through the hole in which the nail is inserted. The paper bags have from four to six holes punched about midway between the top and bottom and are completely immersed in melted paraffin, opened, and allowed to cool. They are placed the same distance from the ground as the cans and are fastened to the tree with an ordinary large carpet tack. A container should be attached to each tree in the orchard overrun with ants. The sirup should be renewed whenever it begins to harden or crystallize. An inspection at least once a month will determine the condition of the sirup and the feeding habits of the ants.

High temperatures, an excessive food supply, and favorable breeding conditions in the ant colony often increase the difficulty of ant control. Control is most quickly effected in the spring or autumn. Normally this will be from the time the ants first become active in the spring until July 1 and from the last of September until the ants again become inactive with the approach of cold weather.

CONTROL METHODS.

FUMIGATION INEFFECTIVE.

Fumigation as practiced in the citrus orchards of California for the control of other citrus pests is ineffective as a means of control of the citrus mealybug. A dosage of over an ounce of cyanid per 100 cubic feet of space in an airtight inclosure would be required to destroy this insect—a dosage which the trees would not endure.

NATURAL CONTROL.

None of the important citrus insect pests in California is more effectively preyed upon by its natural enemies[5] than the citrus mealybug. If the Argentine ant is not present and the enemies of the mealybug are present in sufficient numbers, they will clean up an infestation and hold it in commercial control over a long period.

It is very important first to control the ant by the methods already outlined. The predators and parasites will then increase in numbers and under proper conditions will effect a control.

The distribution of additional predators such as the lacewing flies and the ladybird beetles from the State and county insectaries is highly recommended. This distribution should be made during the spring and autumn months and should follow closely the ant-control work.

SPRAYING CONTROL.

Only in severe infestations is control by spraying necessary. In this work it is desirable to have all fruit removed and the trees pruned so as to permit "open" spraying. A power sprayer carrying at least 350 pounds pressure with spray guns having an $\frac{8}{64}$-inch disk opening are most desirable. Much inside spraying of the trunk and main limbs will be found necessary as well as a thorough application to the outer foliage. Too much importance can not be given to the thoroughness of application or to maintaining a driving mist spray under high pressure.

Mealybug infestations occur largely on the inside of the tree, and it is important that this part receive especial attention from several positions, preferably before the outside of the tree is sprayed. Spraying may be done to the best advantage in the late autumn and winter months. Either of the following insecticides is recommended:

Miscible oils.—A good commercial miscible oil used at the rate of 3 gallons to each 100 gallons of water in the spray tank is not only the most convenient but the safest insecticide to employ. It eliminates the danger of injury from free oil and the possible caustic effect of the soap powder contained in the cresol-soap-distillate emulsion.

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[5] The more effective enemies of this species, including both predators and parasites, given in the order of their importance, are: *Sympherobius barberi* Banks, *S. californicus* Banks, *Hyperaspis lateralis* Muls., *Cryptolaemus montrouzieri* Muls., *Chrysopa californica* Banks, *Leucopis bella* Loew, and *Paraleptomastix abnormis* Girault.

Cresol-soap-distillate emulsion.—A cresol-soap-distillate emulsion may be prepared from the following formula:

Distillate (28° Baumé)	gallons	2½
Liquor cresolis compositus	quarts	1½
Soap powder	pounds	3
Water	gallons	100

Preparation.—(1) When the water in the bottom of the spray tank covers the agitator rod, start the agitator and slowly sift in the soap powder. (2) Add the liquor cresolis compositus to the distillate and stir well. (3) Add the mixture of liquor cresolis compositus and distillate to the soap mixture in the tank and fill the tank with water.

The grade of the distillate and the soap powder used is very important. The distillate should test approximately 28° Baumé and be fairly free from impurities. Certain grades of commercial soap powders emulsify more readily than others, and as the oil is largely held in solution by mechanical agitation it is important to obtain good ingredients. The resulting spray solution in the spray tank should be milky white and free from scum and free oil.

SUMMARY.

The common or "citrus" mealybug seriously affects the fruit of oranges, lemons, and grapefruit. It not only causes premature dropping of the fruit but materially lowers the grade. Heavy defoliation and lowered vitality of the trees frequently follow an infestation.

The Argentine ant bears an important relation to the control of the mealybug and may be controlled by the use of poisoned sirup.

The mealybug is largely controlled by its natural enemies, and with the liberation of certain predators may be effectively controlled.

In severe infestations spray-control methods herein given have proved very effective.

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Fruit Insect Investigations	A. L. Quaintance, *in Charge.*

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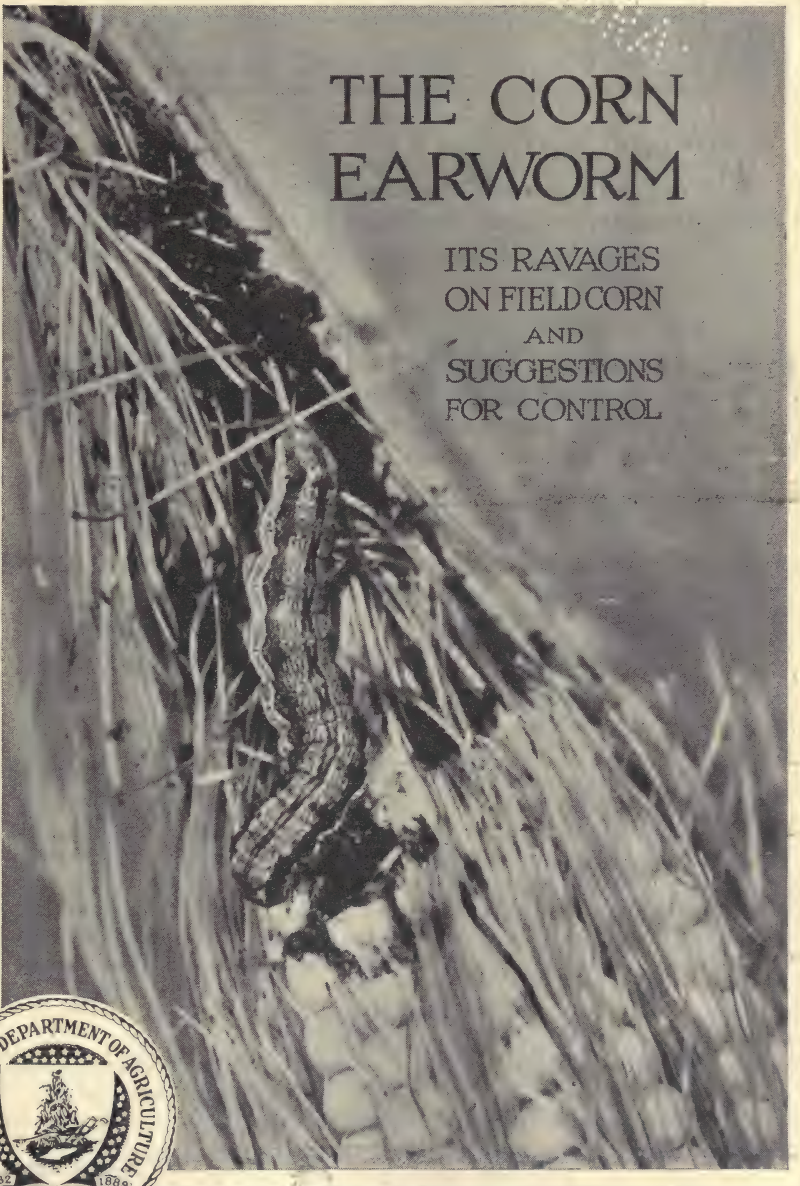
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No.1310



THE CORN EARWORM

ITS RAVAGES ON FIELD CORN AND SUGGESTIONS FOR CONTROL

1862 1889

EVERY CORN GROWER is familiar with the corn earworm, but few realize the full extent of the loss it occasions to the field-corn crop of this country. Conservatively estimated, this loss amounts annually to $40,000,000.

Each grower of corn, with little extra cost or effort, may reduce his loss from earworm ravages by at least one-half if he will select a variety of corn well suited to his local conditions, but having a long, tight husk, and will plant this variety so as to have it silk at the most favorable time—that is, when the moths of the earworm are least abundant.

This bulletin describes the different stages of the insect, and shows how it damages corn, how it is partly kept in check by its own habits and its natural enemies, and how a knowledge of its life history will aid the corn grower in protecting his crop.

Washington, D. C. January, 1923

THE CORN EARWORM:[1]

ITS RAVAGES ON FIELD CORN AND SUGGESTIONS FOR CONTROL.

W. J. Phillips, *Entomologist*, and Kenneth M. King, *Scientific Assistant, Cereal and Forage Insect Investigations, Bureau of Entomology.*

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  Character of husk — 15
  Variety to choose — 15
  Soil productiveness — 16
  Plowing — 16
  Spraying or dusting the silks — 16
  Degree of control possible — 17

THE MOST DESTRUCTIVE CORN INSECT.

THE most destructive insect enemy of corn in the United States is the corn earworm. Its ravages vary considerably from year to year, but the damage during 1921 was perhaps the greatest yet recorded. At present it is the only insect of widespread importance which attacks the immature ears of corn. The earworm occurs throughout the United States wherever corn is grown. Green sweet corn suffers most severely from its attack. While in the North losses are heavy, in the far South the production of this favorite vegetable is rendered almost impossible by the ravages of this insect. Field corn does not suffer so severely, but it has been estimated that 2 per cent of this crop is annually destroyed by the earworm. Even at the low farm valuation of the 1920 crop of corn ($2,189,721,000)[2] this means a loss, for this crop alone, of over $40,000,000. Throughout Virginia and the other Southern States the average percentage of injury to field corn is much higher than 2 per cent, making the corn earworm of particular importance in this region.

OTHER FOOD PLANTS.

Although corn is its favorite food, this insect is also an important enemy of several other crops. On cotton it ranks, in amount of damage done, next to the boll weevil. When feeding on cotton it is called the "bollworm." Under the name of "tomato fruitworm" it is known as a very destructive enemy of early tomatoes. The late broods attack the buds and seed pods of tobacco. On vetch the earworm assumes migratory habits similar to those of the armyworm. Alfalfa is sometimes attacked, especially in the irrigated sections of the Southwest.

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[1] ***Heliothis obsoleta*** Fab.; order Lepidoptera, family Noctuidae.

[2] United States Department of Agriculture Yearbook, 1920, p. 538.

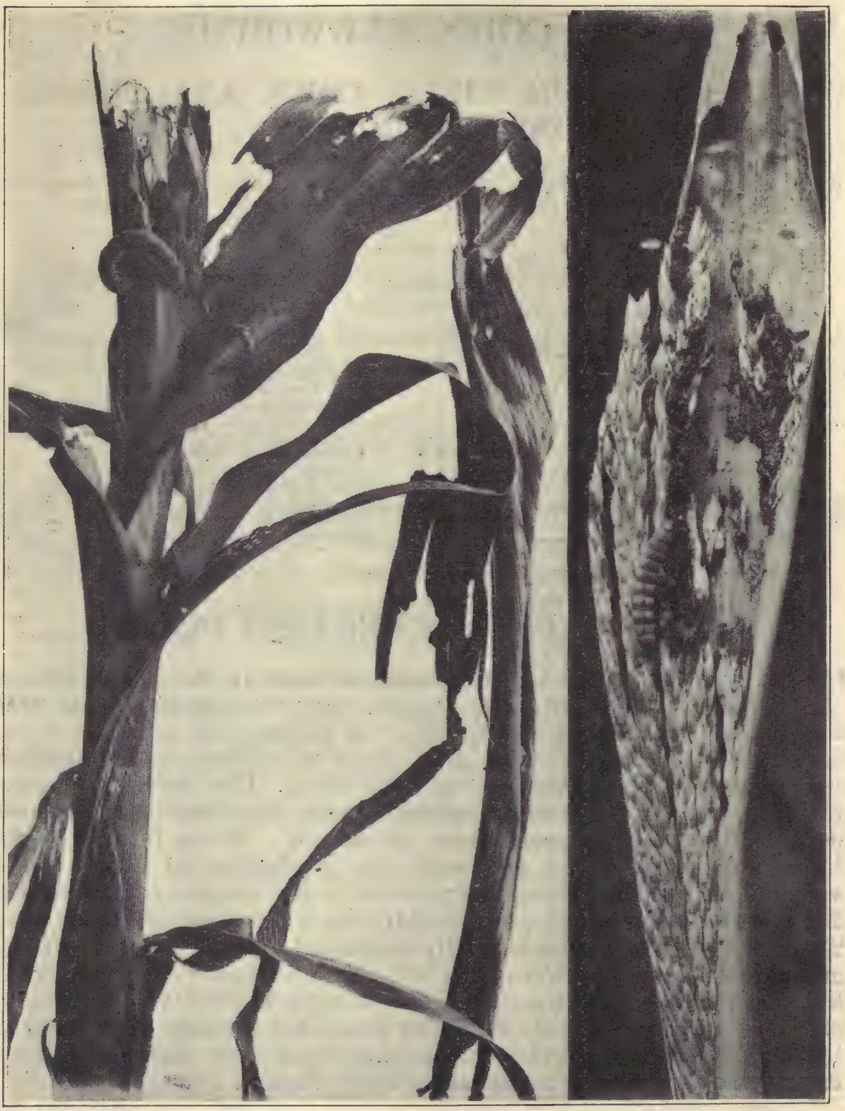

FIG. 1.—Corn earworm injury to bud (at left) and tassel (at right) of corn. Reduced nearly one-half. (Quaintance and Brues.)

In addition to being a major pest of the crops mentioned above, the earworm larvæ can subsist on a great variety of other plants, some of which are cowpea, bean, okra, sunflower, beggarweed, crab grass, castor bean, squash, and green peppers, to mention only a few of the more important ones.

This great variety of food plants renders the control of the corn earworm difficult. It should be remembered, however, that where corn in the milk stage is available this is attacked in preference to any other food.

HOW CORN IS DAMAGED.

In spite of the large aggregate losses due to the work of the earworm on corn, growers generally have become tolerant of the pest. This is largely due to the fact that they have been familiar with its depredations for many years and do not realize the extent of the losses caused by it.

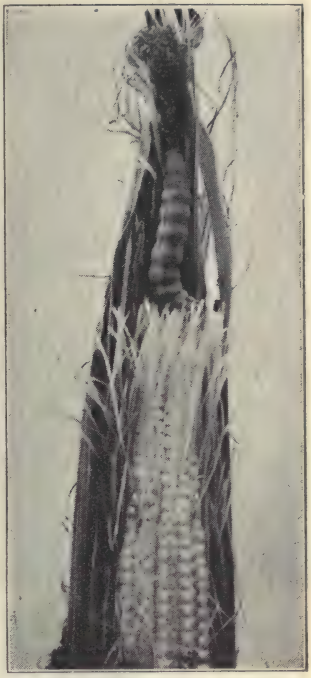

FIG. 2.—Partly grown earworm severing fresh silks before fertilization of the ear is complete. Slightly reduced. (Photo by R. C. Smith.)

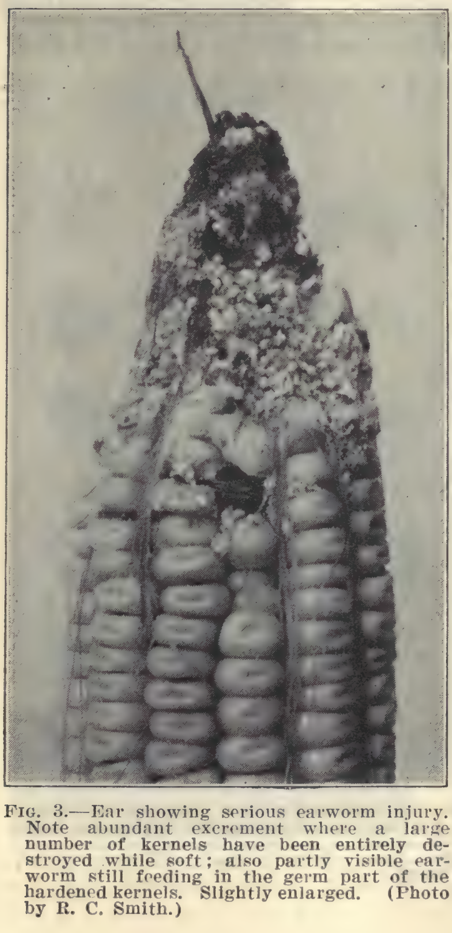

FIG. 3.—Ear showing serious earworm injury. Note abundant excrement where a large number of kernels have been entirely destroyed while soft; also partly visible earworm still feeding in the germ part of the hardened kernels. Slightly enlarged. (Photo by R. C. Smith.)

The damage is caused entirely by the worms or larvæ of the insect. In the early plantings the worms attack the "buds" or central shoots, feeding on the tender unfolding leaves (Fig. 1). The extent of the loss thus caused depends, of course, on the severity of the injury to the bud itself. In 1921 the writers found that plants with "ragworm" or "budworm" injury produced, on the average, 20 per cent less of shelled corn by weight than similar uninjured plants. This loss would be very important were many plants thus injured, but fortunately only a small per cent ordinarily are found with earworms boring in the bud.

When tassels appear the few worms present immediately at-

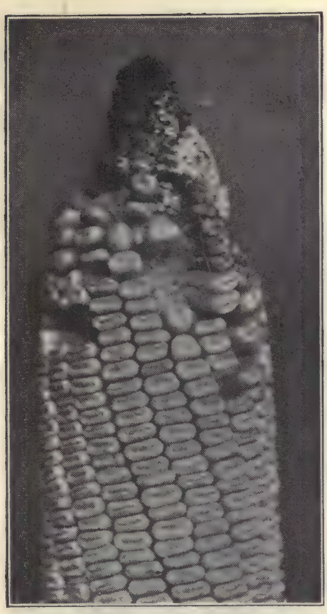

FIG. 4.—Injured ear typical of results of germ feeding by earworm. Note missing kernels. About five-eighths natural size. (Photo by R. C. Smith.)

tack them (Fig. 1), but this feeding is of little or no importance, for the tassels are soon deserted for the ears.

After the silks appear, eggs are laid on them in preference to any other parts of the plant (Fig. 15). The young worms feed on the silks, gradually working into the developing ear. Partly matured worms, coming to the silks from the tassels, may sometimes sever the silks (Fig. 2) before fertilization is complete, causing "nubbins" or poorly filled tips. It is not known to what extent this occurs.

The principal injury occurs when the worms reach the ears, where many of the kernels are destroyed (Figs. 3 and 9) while still soft. As the kernels harden, the worms sometimes leave the corn for other food plants, but in Virginia they more often burrow under the kernels, feeding on the germ parts (Figs. 3 and 4), which remain soft for a longer period. This type of injury is important, as such kernels drop out during shucking and handling (Fig. 5) and become a total loss. Careful investigation in Virginia has shown that the actual feeding of earworms on the kernels causes from 1 per cent to 17 per cent reduction in weight of shelled corn. The writers observed one field, grown under exceptionally unfavorable conditions, where the loss due to earworms was easily 50 per cent of the crop.

The indirect injury to the ears which results from the work of the earworm is sometimes as important as the direct loss. Molds which would not otherwise gain entrance to the ears are carried in by the worms or enter with the rain through holes in the husk (Fig. 6) bored by ear-

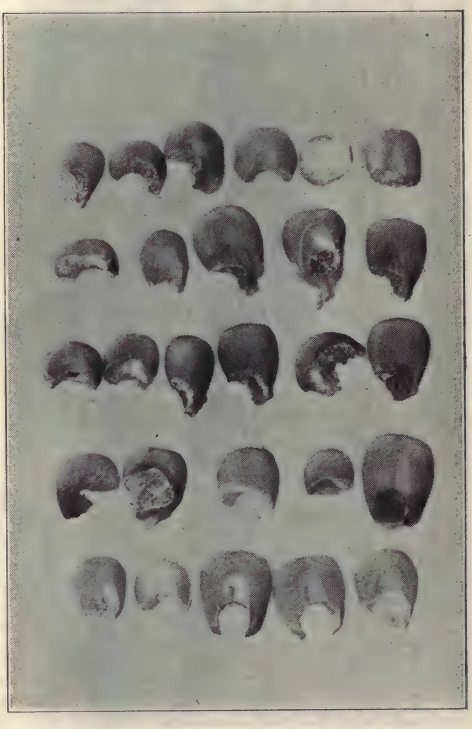

FIG. 5.—Hardened kernels with germ portions destroyed by earworms. Such kernels drop from ears during handling and represent serious loss. Natural size. (Photo by R. C. Smith.)

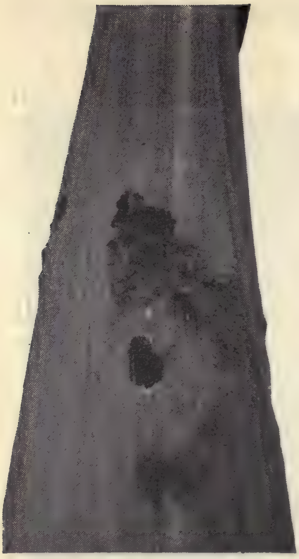

FIG 6.—Hole through husks made by earworm; such openings afford entrance to rain, molds, and weevils. About natural size. (Photo by R. C. Smith.)

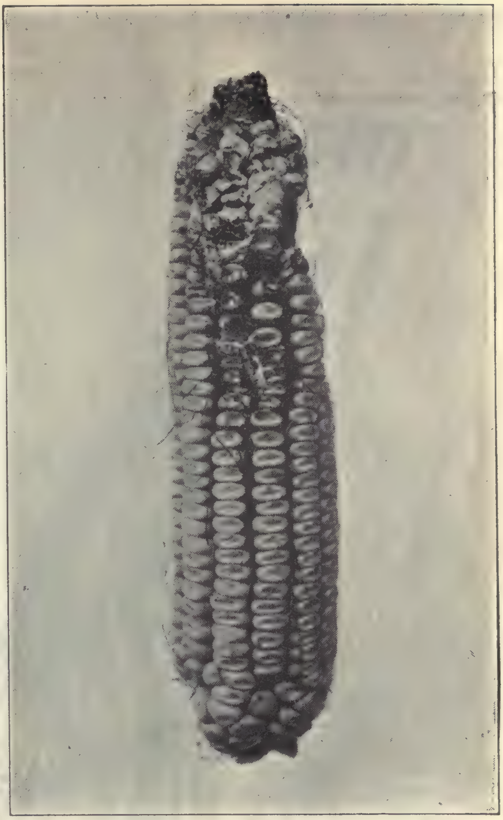

FIG. 7.—Severe earworm damage followed by mold injury. Reduced about one-half. (Photo by R. C. Smith.)

worms or at the tip where silks severed by the larvæ have fallen out (Fig. 2). Within the ear, molds breed upon the mass of excrement (Fig. 3) and damaged kernels (Fig. 7) left by the worms and often destroy the remaining uninjured kernels. Ears severely injured by molds are unsafe to use for feeding purposes, especially as food for horses.

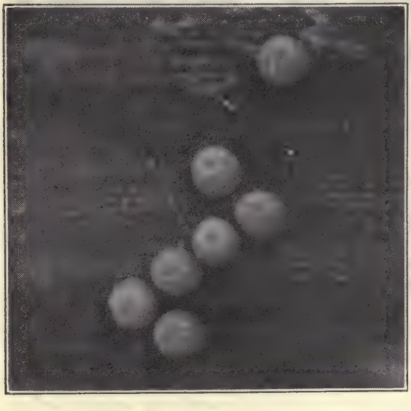

FIG. 8.—Eggs of earworm on corn leaf. Greatly enlarged. (Photo by R. C. Smith.)

Other insects, such as the grain beetles and weevils, which are unable to enter through sound, long, tight husks, often gain admission to the ears through husks (Fig. 6) or silks (Fig. 2) injured by earworms. In the far South the work of these pests is very important. They could be largely controlled by reducing earworm injury.

It is impossible accurately to estimate the loss which in these ways is indirectly due to the earworm feeding. It is probably at least half as great as that caused by direct injury.

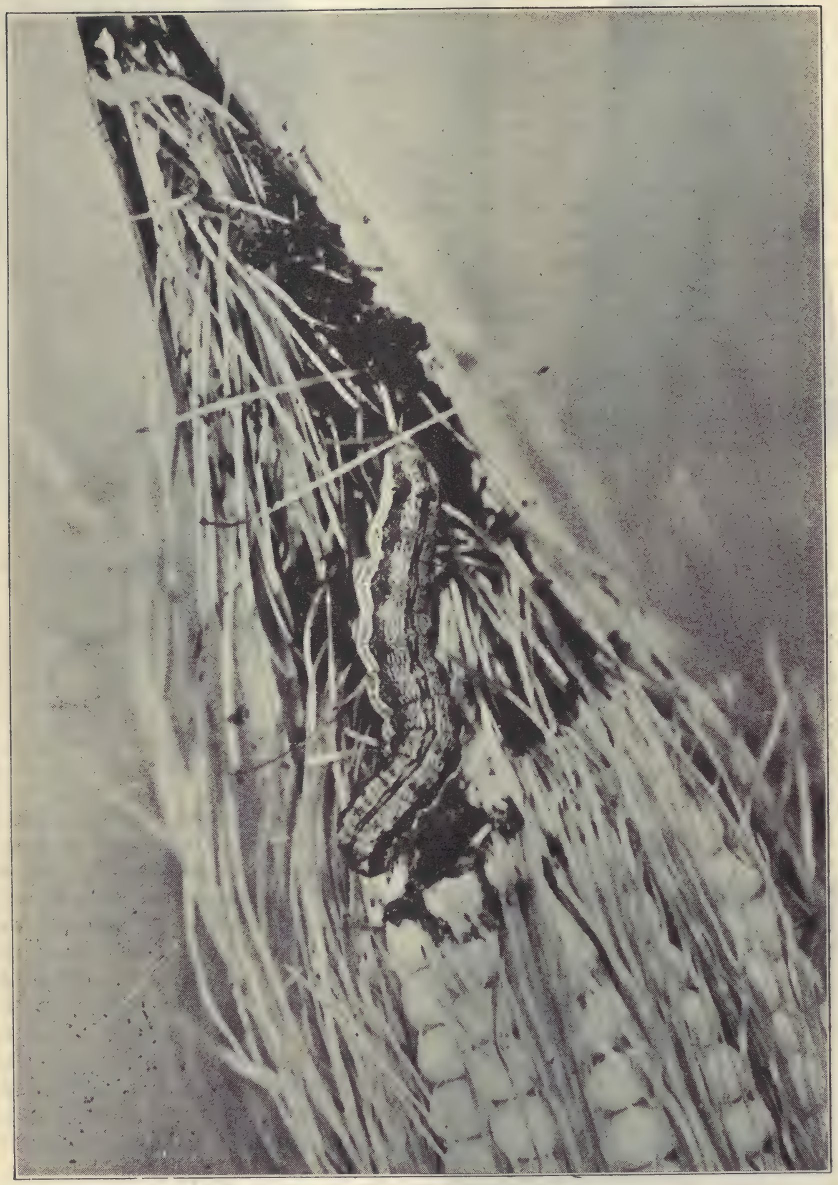

FIG. 9.—Nearly full-grown earworm devouring silks and soft kernels of sweet corn. Note typical striped appearance of the larva. About 1½ times natural size. (Photo by R. C. Smith.)

OTHER INSECTS CAUSING SIMILAR INJURY TO CORN.

Several other insects cause injury to the buds of young corn similar to that caused by the earworm. Among these are the larger corn stalk-borer [3], the Southern corn rootworm,[4] and the stalk-borer.[5] Where a grower has widespread injury of this type he should appeal to the entomologist of his own State or to the United States Department of Agriculture for identification of the species involved and information as to control measures.

In its feeding on the ear of corn, however, the work of the earworm is distinctive, although in some parts of the Corn Belt the fall armyworm [6] is often found in numbers feeding in the ears of late-maturing corn, and an occasional cutworm makes its way to the ear.

Another insect causing somewhat similar injury to the ears of corn is the European corn borer.[7] This pest has only recently gained admission to the United States and fortunately has as yet spread to only a small part of the corn-growing regions. Its work is readily distinguished from that of the earworm. When present the corn earworm almost invariably attacks the ears and seldom bores into cob or stalk, whereas in light infestations the European corn borer normally attacks the stalks, rarely attacking the ears. As the intensity of the infestation increases, the ears also become infested, the worms often boring up through the shank. In fields infested with the European corn borer a large number of the tassels often are broken over. Examination at the point of breakage shows a small hole filled with frass or "shavings" of the borer, and the center of the stem shows its work. This insect is present as a caterpillar in the stalks and ears of corn throughout the fall and winter, whereas during that period the corn earworm exists only as a pupa in the soil.

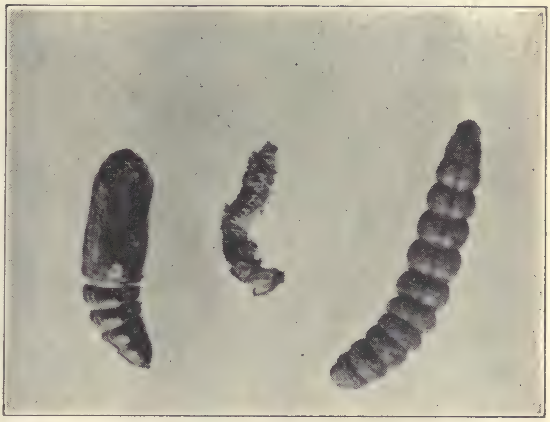

FIG. 10.—The corn earworm. At right, larva after entering ground and ready to pupate; in center, cast skin; at left, pupa. Slightly enlarged. (Photo by R. C. Smith.)

HOW TO RECOGNIZE THE EARWORM.

During its lifetime the corn earworm passes through four very distinct stages—the egg (Fig. 8), the larva or worm (Fig. 9), the pupa (Fig. 10), and the moth or adult (Fig. 12). Few growers, however, are familiar with it except when, as a partly grown worm, it is feeding voraciously in the ear.

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[3] *Diatraea zeacolella* Dyar.

[4] *Diabrotica duodecimpunctata* Oliv.

[5] *Papaipema nebris* Guen., form *nitela* Guen.

[6] *Laphygma frugiperda* A. & S.

[7] *Pyrausta nubilalis* Hbn.

If the leaves are carefully examined in the spring a few eggs may be found. Later, when the silks are beginning to appear, the eggs are more easily detected because large numbers are often laid on the silks of a single ear (Fig. 15).

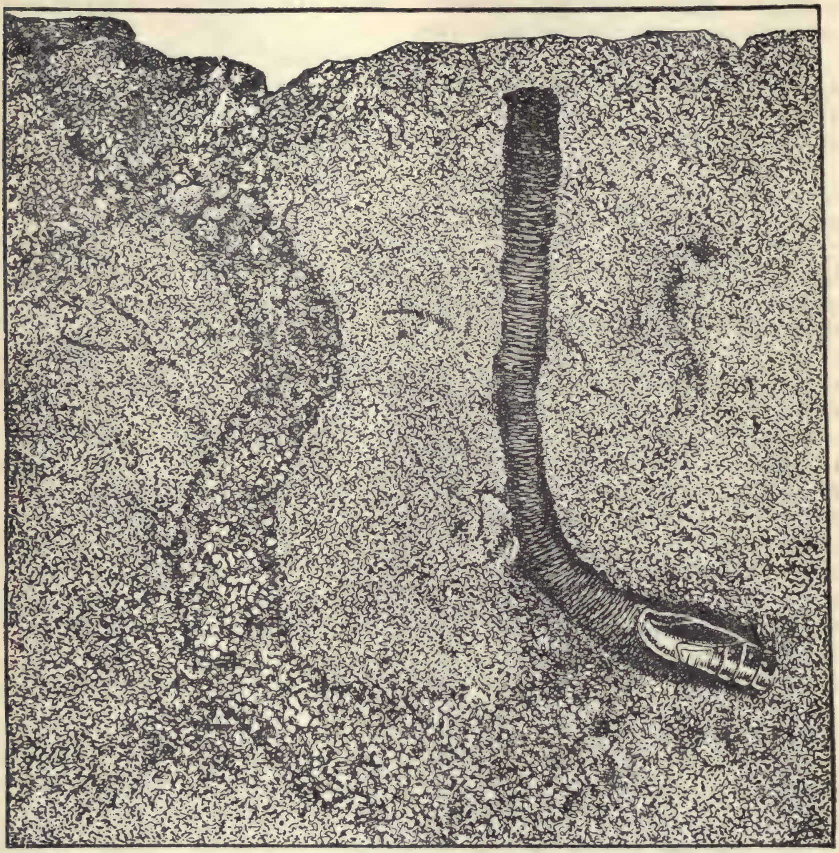

FIG. 11.—Pupa of the earworm in its burrow in the soil. Note the disturbed soil where the larva worked its way down, and the smooth channel constructed for the escape of the moth. Somewhat enlarged. (Drawn from Quaintance and Brues.)

THE EGG.

The egg (Fig. 8) is about half the size of the head of a common pin. It is shaped like a ball flattened at opposite ends. When first laid it is light yellow, but appears white against the dark green of the corn plants. It soon darkens and when ready to hatch has become a dusky brown. Hatching occurs from two to eight days after the egg is deposited, the length of time depending on the temperature.

THE LARVA OR EARWORM.

The newly hatched caterpillar is whitish, with a black head, and is very small. Growth is very rapid. The worm attains full size in from 13 to 28 days after hatching. The increase in size is accomplished in a way known as molting. Every 2 to 5 days the old hard skin is split down the back and cast off and the worm expands greatly in size before the new skin has become hardened. Usually five molts occur during the process of growth. Each molt is preceded by an inactive period of some hours, during which the larva is helpless. When full grown (Fig. 9), the earworm is about 1½ inches long and very robust. The coloration at this time varies to a marked extent, the extremes being pale green and very dark brown. When one has become acquainted with the habits, arrangement of the stripes, and general robust appearance of the earworm, it is not easily confused with any other insect found on corn. The best way to become familiar with the larva is to open several ears of corn in midsummer and examine the larger worms (Fig. 9).

THE PUPA OR RESTING STAGE.

When full grown the larva leaves the ear, usually by boring out through the husks (Fig. 6), and drops to the ground. It enters the soil as soon as possible, and bores down to a depth of from 1 to 7 inches, varying with the hardness of the soil, moisture, and weather conditions. The larva then forms a cell (Fig. 11). In order that the moth may easily reach the surface, a smooth open passageway is constructed from the cell to within a short distance of the surface; then the larva returns to the cell, where it transforms into a pupa (Figs. 10 and 11). During this resting stage the great changes take place by which the worm becomes the moth. The pupa is light brown, about three-fourths of an inch long, and rather stout. It is very delicate and helpless. Many are destroyed by moles and other enemies, and by the disturbance of the cells in the process of plowing or harrowing. When the changes are complete the moth emerges from the pupa and makes its way to the surface, where the wings expand and harden. In midsummer the period from the time the larva leaves the ear until the moth emerges may be as short as 14 days. It is usually somewhat longer, and it may be several months, as the winter is passed while the insect is in the pupa stage.

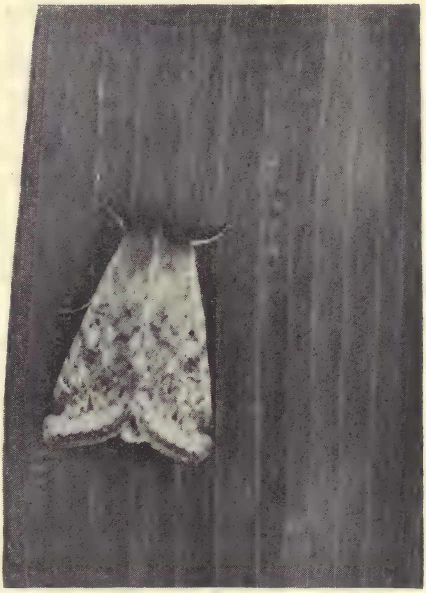
FIG. 12.—The adult or moth of the earworm resting on corn leaf. Slightly enlarged. (Photo by R. C. Smith.)

THE MOTH OR ADULT.

The moth (Fig. 12) is about three-fourths of an inch long and has a wing expanse of 1½ inches. The coloration is dull and the shades vary considerably from a light olive green to a rather dark reddish brown. Although itself seldom attracted to lights, it is similar to those moths which are common about lights in the summer. The moth makes itself so inconspicuous that the grower will seldom see one, unless it is noticed at midday resting in the throat of a corn plant. The moths become active in the early evening, feed on the nectar of various flowers, and then fly in search of suitable plants on which to lay their eggs.

Soon after emergence, mating takes place and egg laying begins. Each female deposits many eggs in an evening, distributed over a number of plants taken at random. The eggs are laid singly, but many may be laid on parts of one plant before another is visited. The females live about 12 days, and during this time each may deposit between 400 and 3,000 eggs, the average being about 1,000.

SEASONAL DEVELOPMENT.

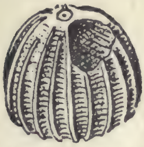

FIG. 13.—Earworm egg parasitized by *Trichogramma minutum*. Greatly enlarged. (Quaintance and Brues.)

The variation in the time required for each stage is due to variations in temperature. If each stage were passed in the shortest time as given above, the entire life cycle could be completed in a month. In other words, under the most favorable conditions it will require only 30 days from the time an egg is laid until the adult insect appears. In the southern part of the United States this does occur in midsummer, and there may be as many as seven generations of the earworm annually. In the extreme northern part of the country, however, there is only a single generation each year. Between these extremes the number of generations varies with the latitude, altitude, and other factors which influence seasonal temperatures. Throughout the greater part of the Corn Belt there are three or four broods annually. The number of generations largely determines the destructiveness of this pest in any given area.

In Virginia moths begin to emerge from the overwintering pupæ during the latter part of May. Eggs of the first generation are most abundant during the latter part of June and the first two weeks of July. In the latter part of July or the first part of August, depending on the season, there is usually a period during which few or no eggs can be found by the most careful observation. Moths of the second generation soon appear, and eggs are deposited in greater abundance than before. From that time until frost eggs may always be found, the broods overlapping, though the eggs are more abundant at some periods than at others. The earliest moths of the third generation appear during the latter part of August. In Virginia it is this generation which passes the winter in the pupa stage.

Farther South the moths appear earlier in the spring, attacking corn, vetch, and tomatoes. The later generations develop on late corn, cotton, and tobacco.

NATURAL AGENCIES OF CONTROL.

CANNIBALISM.

The most important factor tending to reduce earworm ravages on corn is the earworms' habit of cannibalism. Wherever two worms come into chance contact with each other they fight until one is conquered. Often the uninjured worm entirely consumes its foe. Since by far the greater number of the newly hatched worms enter the ears through the silks, contact is very frequent and only a few worms survive to reach the ear. This is especially true where husks are long and tight (Fig. 17), because, in this case, the silk channel is long and narrow, and the chances for more than one survivor are greatly lessened. When husks are short or loose (Fig. 16), worms easily find their way to various parts of the ear without feeding on the silk or disturbing one another. When thus widely separated they feed unmolested and many more reach maturity. Comparatively few worms enter the ear by boring through the husk.

PARASITES AND PREDACIOUS ENEMIES.

A tiny egg parasite [8] attacks many of the eggs (Fig. 13), especially those on the leaves. Occasionally in some seasons nearly all of the eggs fail to hatch because of the work of this insect, while at other times only a few are destroyed. This parasite is very helpful, but would aid even more were means found to render it more dependable. Its work is greatly supplemented by that of a small bug [9] (Fig. 14), which, especially in late summer, destroys many of the earworm eggs laid on corn silks. This little predator appears to be of special value in Virginia.

Several other insects attack many of the eggs and young worms before they enter the ears. Among these enemies are two species of ladybird beetles,[10] a larger bug,[11] lacewing flies,[12] certain ants, and spiders common in cornfields.

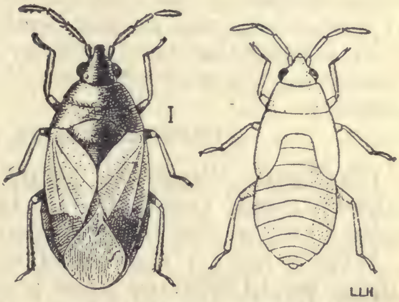

Fig. 14.—*Triphleps insidiosus:* Adult and nymph. Destroys large numbers of eggs and young larvæ of the earworm. Greatly enlarged. (Quaintance and Brues.)

After the worms enter the silks they are well protected from most enemies until they leave the ears. Active, dark-colored beetle larvæ [13] are important destroyers of the later broods of earworms in some sections. These predators follow their prey into the ears and kill many of them. In the fall they enter the soil and undoubtedly destroy many of the overwintering pupæ.

A few insects are parasitic on the larger earworms. A fly [14] similar in appearance to the house fly is of much importance when the corn earworm is feeding exposed on cotton and vetch, but is of little aid when corn is the food plant.

Three species not hitherto recorded as preying on the earworm have been reared from these larvæ in Virginia. A large four-winged fly[15] attacks the larger larvæ and is the most important larval parasite the writers have found. A smaller species[16] has been reared from the smaller worms. A two-winged fly[17] has also been reared from the earworm.

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[8] *Trichogramma minutum* Riley.

[9] *Triphleps insidiosus* Say.

[10] *Ceratomegilla fuscilabris* Muls. (*Megilla maculata* auct.) and *Hippodamia convergens* Guér.

[11] *Nabis ferus* L.

[12] *Chrysopa* spp.

[13] *Chauliognathus marginatus* Fab.; *Chauliognathus pennsylvanicus* De G.

[14] *Winthemia quadripustulata* Fab.

The Bureau of Biological Survey of this department has records showing that 17 species of birds feed on the corn earworm and that the most important of these seem to be the Brewer and California red-winged blackbirds, the boat-tailed grackle, and the downy woodpecker. As many as 10 larvæ of the earworm have been found in a single stomach of the cardinal and more than 50 in one of the boat-tailed grackle.

WEATHER CONDITIONS.

Weather conditions sometimes aid in control. Heavy rainstorms destroy many eggs. Early severe frosts in the fall kill many worms before they have entered the soil. Severe winter freezes aid in destroying many pupæ. In addition, the pupæ suffer from the attacks of mice, moles, and ground beetles.

No attempt has been made to list all the parasitic and predacious enemies of the earworm, but only the more important ones are mentioned.

IMPORTANCE OF NATURAL AGENCIES.

Considered collectively, all these factors of natural control explain why only one, two, or rarely three larvæ mature on a corn plant upon which several hundred eggs have been deposited.

Were it not for the important aid rendered by these agencies the injury would be many times greater and would probably make corn growing very difficult indeed. Unfortunately, these natural agencies do not effect a sufficient degree of control to render artificial measures unnecessary.

CONTROL MEASURES.

The character of the corn crop is such as to make control of any of its insect pests unusually difficult. Expensive methods are not justifiable because of the small margin of profit and the relatively low commercial value of the crop. Furthermore, it is grown over such large areas that individual treatment of each plant is impracticable. The corn earworm is especially difficult to control because of the fact that for the greater part of its life it feeds in a protected position and can not be reached by poisons.

Spraying or dusting of the whole corn plant on a large scale is costly and ineffective. A fair degree of control may be obtained by dusting the silks, but this method is expensive and impractical for the crop as a whole.

No grower should assume from the preceding discussion that it is hopeless to expect any great reduction in earworm damage. By using the methods described herein any grower can greatly reduce his losses; and if an entire community would uniformly put these methods into practice, the results would undoubtedly be remarkable and could be effected with little cost.

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[15] *Paniscus* sp., near *geminatus* Say.

[16] *Sagaritis dubitatus* Cress.

[17] *Sarcophaga latisterna* Park.

Previous estimates of the damage done by this insect have been based on percentage of infestation, but the writers have found that the percentage of infestation is not an accurate index of the accompanying injury. By finding the total weight of shelled corn produced and the weight of kernels equivalent to those injured by the earworm, the per cent of loss can be accurately calculated. The following recommendations for control measures are, for the most part, based on fairly accurate percentages of loss under the various conditions, as found in this manner.

TIME OF PLANTING.

In Virginia the time of planting, or rather the time of silking, has been found to be the most important factor affecting earworm damage. The moths much prefer to deposit their eggs on fresh moist silks (Fig. 15), and few are placed upon plants which have dry silks. Where the crop of field corn can be brought into silk at the period when moths are least abundant, the infestation and damage are greatly reduced. With corn silking at the most favorable time, the percentage of loss has been found to be only one-fifth to one-half as great as for corn silking at any other period. This most favorable period varies with the locality and the season, and therefore the exact date of planting which each grower should use can not be definitely stated here for the country as a whole. At Charlottesville, Va., it has been found that Virginia-grown seed of Hickory King or Reid's Yellow Dent should be planted about the middle of May in the average season. Each grower should select the date that he finds best for his locality and the varieties that he grows.

In general the late-maturing and prolific varieties, which have been found to produce best on rich soil, should be planted as early in the season as is consistent with conditions favorable for germination and growth. Too early planting should be avoided, of course, because it may result in poor germination, necessitating replanting, and in slow growth and reduced yield. Replanting tends greatly to increase earworm injury and should be avoided. All of these factors considered, the first week in May is the best planting date in the vicinity of Charlottesville, Va., for long-season varieties. Midseason and early varieties should be planted somewhat later, in order that all plantings may silk at approximately the same time. Early plantings of early varieties are usually as severely injured by the earworm as late plantings of long-season varieties, because in each case the corn silks at a period of great abundance of moths.

In some areas severe injury by other insects makes early planting inadvisable. In such communities it is especially important to arrange it so that the main crop of corn all comes into silk at about the same time. A period of two or three weeks is allowable. Heaviest damage occurs when a field of late corn comes into silk at just the time when moths are emerging from near-by fields of early corn or other food crops. One instance of nearly 50 per cent loss in weight has been observed where a crop of field corn was grown under such conditions.

In sections where corn is the only important food crop of this insect the uniform and rather early silking period of the main crop will greatly reduce losses for the current year, and the lack of suitable food for the late broods will greatly lessen the number of overwintering pupæ, thus reducing the infestation for the succeeding year.

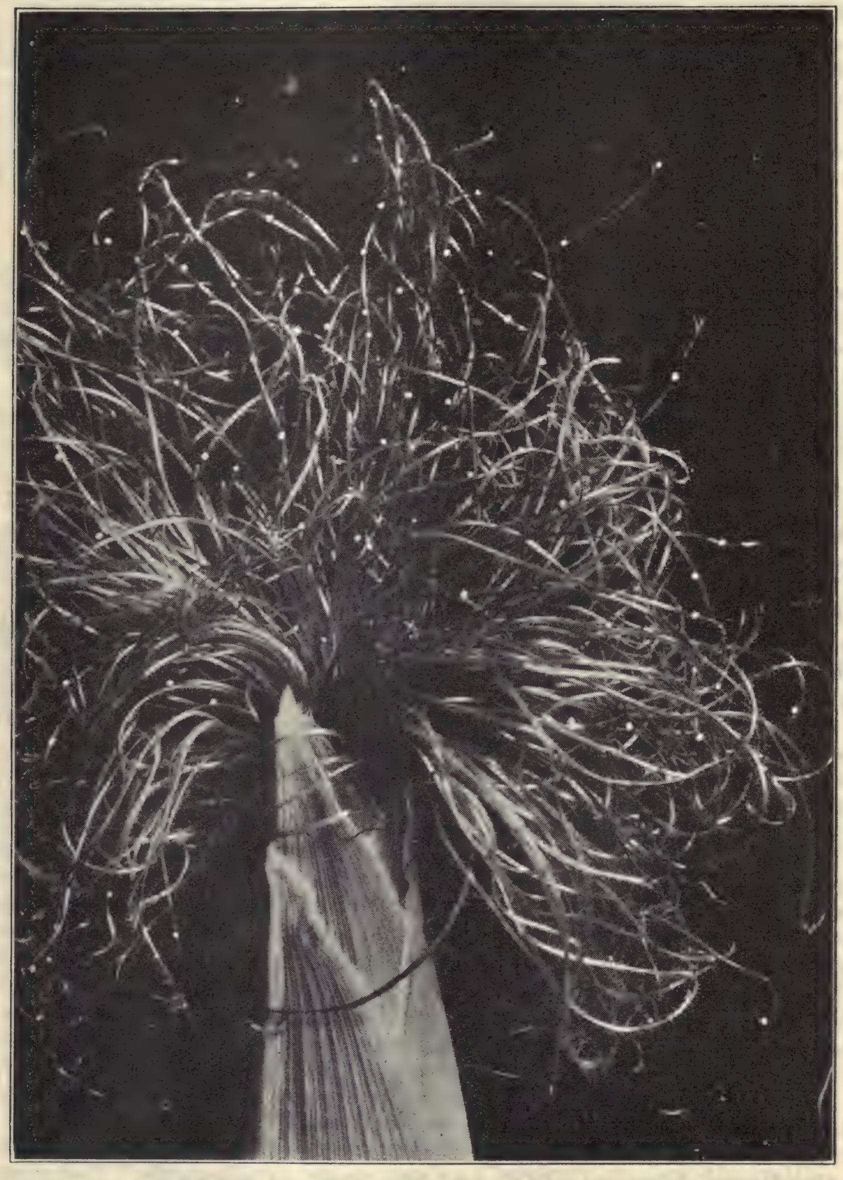

FIG. 15.—Ear in prime silk, at the stage when it is most attractive to the earworm adults for egg laying. Note the large number of eggs scattered through the silks. Slightly enlarged. (Quaintance and Brues.)

CHARACTER OF HUSK.

The character of the enveloping husk is a very important factor influencing earworm injury to corn. It is very desirable that the husk be at least long enough to cover well the tip of the ear, and above all it should close tightly around the silks. The writers have found that ears so protected have only half the loss in weight shown by ears of the same variety grown under identical conditions, and with the same percentage of infestation, but having loose husks. This has held true for nine varieties having different husk characters. Where husks are tight, ears with very long husks are somewhat less damaged by the earworm than ears having only moderately long husks. Moreover, very long, tight husks have been found to be of great assistance in reducing weevil injury to corn. Bird injury to corn in the field is much less in ears with long, tight husks than in those having short or loose ones (Fig. 16). Where these types of injury are important the grower and corn breeder should select for seed ears having husks which are not only tight but also quite long (Fig. 17). By such wise selection, the corn grower can obtain these desirable husk characters in the variety which he has found best suited to his needs and greatly reduce the losses from these various causes.

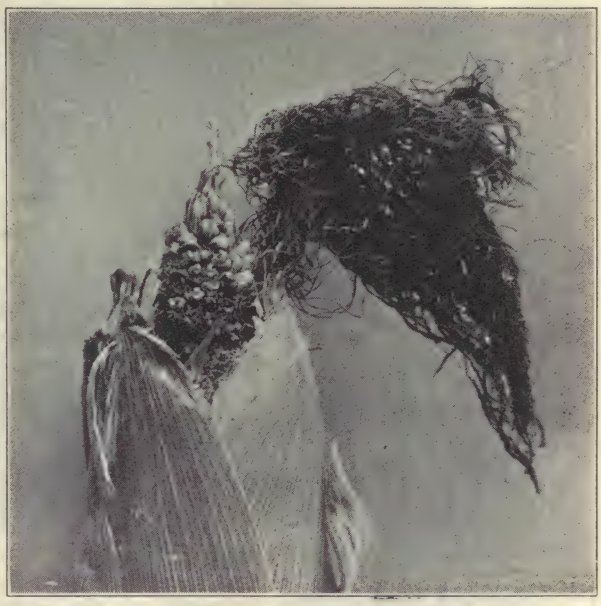

FIG. 16.—Undesirable husk characters. Note bird injury to exposed tip. Ears having husks of this type are especially susceptible to earworm injury. (Photo by R. C. Smith.)

VARIETY TO CHOOSE.

Varieties silking at the same time differ greatly in percentage of loss sustained from the earworm, and such variations are largely explained by the husk differences. The variety selected should be well suited to the local conditions. Late-maturing and prolific varieties when planted on thin land do not silk uniformly; they produce a large proportion of small ears and "nubbins," and are therefore more heavily damaged by earworms than smaller, earlier varieties.

SOIL PRODUCTIVENESS.

To plant corn on poor land is to invite severe earworm injury. This is because of the irregular silking and high percentage of poor ears on such soil. Fertilization, crop rotation, the use of legumes, and other measures which increase the productiveness of the land and make for a better crop of corn aid in reducing the severity of earworm injury.

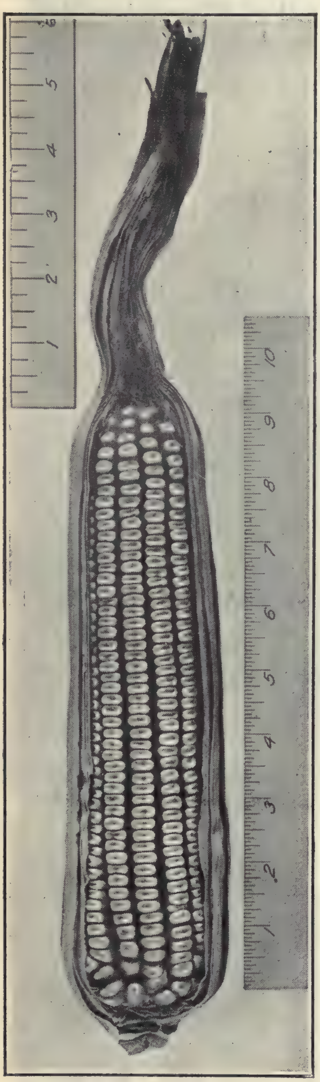

FIG. 17.—Desirable husk characters. Shuck protection like this will greatly reduce both earworm and weevil injury (Kyle.)

PLOWING.

Many writers have recommended that fields bearing crops upon which the earworms feed be plowed in the fall or winter, in order to break up the pupal cells and expose the delicate pupæ to the winter freezes. The present writers have found that in heavy soils the *time* when plowing occurs is of little consequence, as the pupæ are destroyed by this disturbance in any case. Light, friable, or sandy soils, however, that react quickly to atmospheric changes, should be plowed in fall or winter so that advantage may be taken of the destructive effects on the pupæ of frequent changes in temperature. Undoubtedly marked results could be obtained if the farmers of an entire community would plow, during the fall or winter, all the fields that have produced late corn or other crops upon which the late broods of earworms have developed. Unless all places where the insect may be found hibernating can be reached, the expense of fall plowing undertaken for this purpose alone may not be justified by the results obtained.

SPRAYING OR DUSTING THE SILKS.

The application of arsenical sprays or dusts to the silks at the time when these are attractive for oviposition is an effective means of earworm control if properly done. Because of the labor involved, however, this method is prohibitive in cost for the main crop of field corn. It is advisable for market gardeners growing sweet corn, or if corn is specially desired for seed or show purposes, where the increased value of the corn will justify the cost of treatment.

Dusting by hand, using a small sack, or a can with a top perforated like a salt shaker, is the best method of application. A mixture, half arsenate of lead and half finely ground sulphur, has been found most effective. The first application should be made when about one-fifth of the plants have silks at the stage shown in Figure 18. The treatment should be repeated every three or four days until the silks are all dry or the ears are ready for use. There is no danger from the use of these ears as food. The treatment is especially effective where the ears treated have long, tight husks which compel most of the worms to feed on the exposed silks before gaining entrance to the ears.

The writers have found, with field corn, that where heavy driving rains occur during the period of treatment, a considerable amount of rotten corn results. This is apparently due to the action of arsenicals driven by rain into the silks and ears.

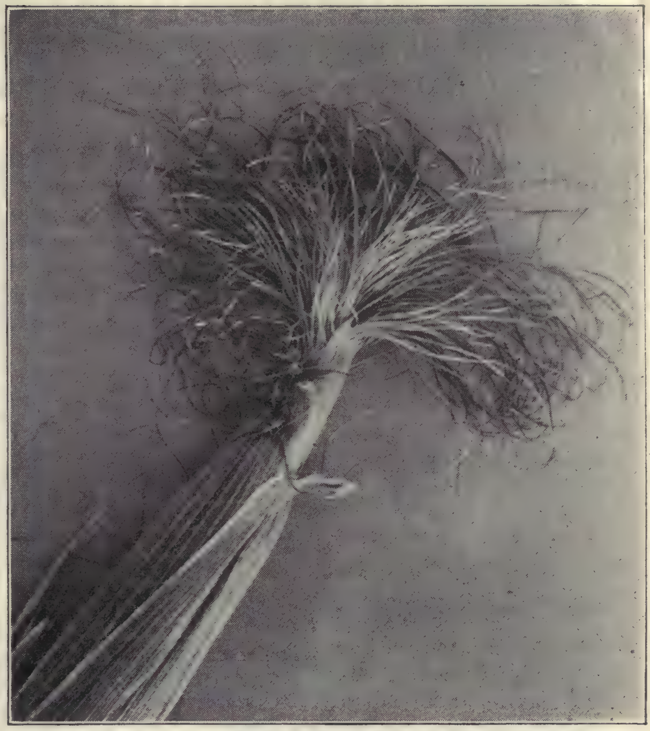

Fig. 18.—Tip of ear showing silks at the stage when dusting should begin. (Photo by R. C. Smith.)

DEGREE OF CONTROL POSSIBLE.

A question which naturally will arise in the grower's mind is, To what degree can this insect be controlled by the use of the cultural methods described in this bulletin? The writers have found that a very marked control is possible. In 1921, a year of very heavy infestation, the ears which had long, tight husks, which silked at the most favorable time, and were of a variety well suited to local conditions, had less than one-half of 1 per cent of the corn eaten by earworms. On the other hand, the worst injured variety and planting showed 17 per cent loss. This difference shows the degree of control effected by changes in cultural practice alone, without the use of arsenicals, and in the absence of community cooperation.

It appears that any energetic grower, with very little expense and moderate effort, can reduce by half the earworm injury to his field corn. A community effort would doubtless effect much better results.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No 1311

CHRYSANTHEMUMS

FOR THE HOME

1862 1889

AMONG HARDY PERENNIALS used for the decoration of yards and gardens some few families stand out above their fellows, so that they form the backbone of any scheme of herbaceous planting. The identity of these plants of prime importance varies somewhat with the geographical situation.

Chrysanthemums are of little value as hardy plants in the extreme North, but can be grown with success over most of the country remaining, and if frost-proof storage space can be given they can be maintained even in the North.

In the amateur's garden chrysanthemums require very simple treatment and yield large displays of flowers. Their range of color and form is wide and permits the gratification of personal taste in their selection.

Although chrysanthemums may be grown from seed, they are usually raised from cuttings or divisions of established plants. These, like the seedlings, come to full maturity and flower profusely in a single season and, in turn, furnish material for propagation the following year.

The plants require for their best development a rich well-drained soil, an abundance of light and air, sufficient room to develop into good bushes, and annual division and replanting in newly fertilized soil.

Washington, D C. Issued November, 1923

CHRYSANTHEMUMS FOR THE HOME.

By B. Y. Morrison, *Assistant Landscape Gardener, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

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THE POPULARITY OF THE CHRYSANTHEMUM.

CHRYSANTHEMUMS are one of the striking features of the autumn garden, for no other plant in bloom at that time has so great a range of color and form. Indeed, when one considers the material available to-day, it seems a far cry from the chrysanthemums which were first brought from the Far East in 1789. The history of the chrysanthemum between the arrival of the first plants and the present day records the usual difficulties attending any new introduction, but interest rarely flagged, because of the fact that the flowers quickly produced variations, both of seed and sport, so that a constantly increasing number of varieties could be disseminated. The chrysanthemum specialist soon developed and has continued until the present time both in Europe and America, where the interest is no less great than in the Orient.

The development of the chrysanthemum has been distinctly a commercial affair, in which the chief purpose has been to secure a strain of large-flowering plants with a long duration of bloom. Attending this process numberless variations of size, shape, and color have appeared (fig. 1), all of which have been perpetuated because of their value as decorations for both conservatory and garden.

For the amateur gardener the large-flowered commercial kinds are of relatively less value, unless he lives in a climate where frosts come late or not at all. There are, however, enough kinds which he can grow to more than make up for any lack of flowers of this type. In fact, there are chrysanthemums for almost all outdoor gardens, no matter where they may be, except in the extreme northern States and in the arid regions or hot wind-swept sections of the Great Plains. In most States north of the Ohio River and north of central New York only the most enduring varieties of the chrysanthemum are hardy, but the summer is long enough to permit bloom on the early-flowering sorts, which can be grown almost like bedding plants and wintered in frost-proof frames or cellars. In all the interior States which are subject to hot, drying winds during the summer special care must be taken in locating the bed to prevent the ruin of the foliage. In the Southern States, however, the chrysanthemum finds locations best suited to it and rewards the grower with a lavish display of bloom which might well be envied farther north.

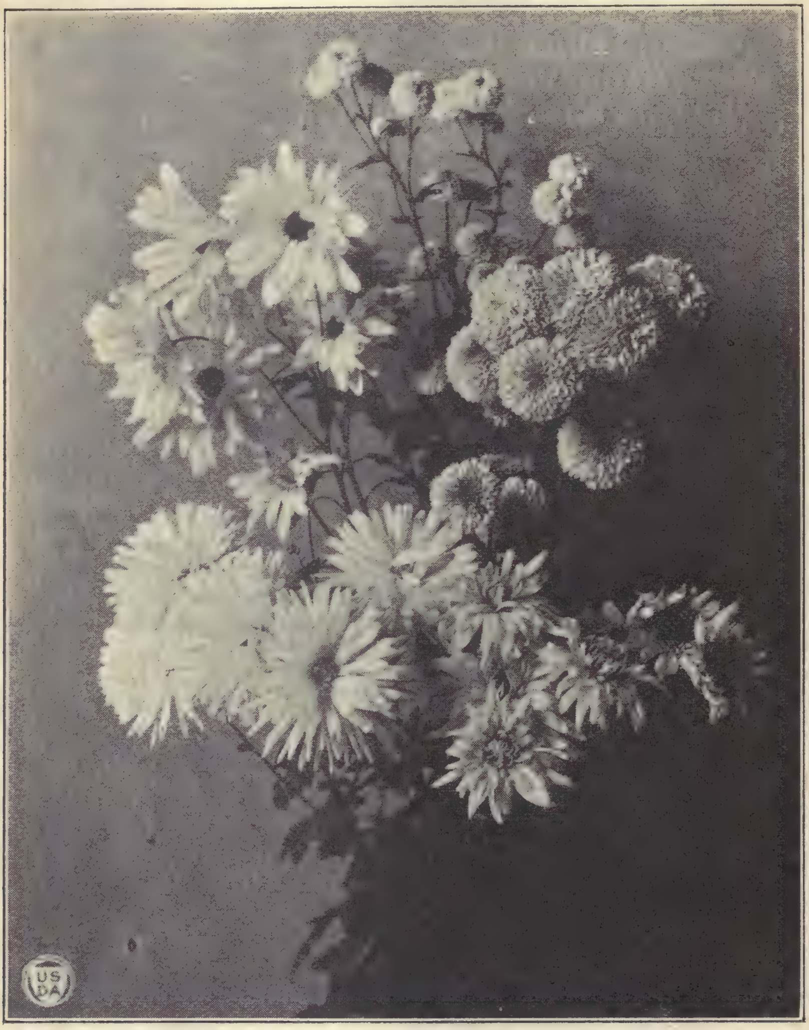

FIG. 1.—Chrysanthemums, showing the many variations of size and shape found in the blooms.

When grown at its best, the chrysanthemum is essentially a plant for the careful and painstaking gardener. Many will survive the vicissitudes of the amateur's hardy garden, but the results are far from the best. The cultural methods described in the following pages represent the better practice for the amateur, although many gardens are known to the writer in which chrysanthemums are left year by year without more attention than is given hardy plants, such as peonies.

CULTURE.

When new garden chrysanthemums are received from the nursery they are commonly small pot-grown plants which have been raised from cuttings. (Fig. 2.) They may be divisions of old clumps, however, with new growths attached to the base of the dead stems from last year which can sometimes be divided into single shoots. In either case they are ready to be planted in the open. If they are to be located in a border of mixed perennials, the soil in which they are planted must be thoroughly enriched with well-decayed manure, because the chrysanthemum is a gross feeder, needing ample supplies to bring its flowers to perfection.

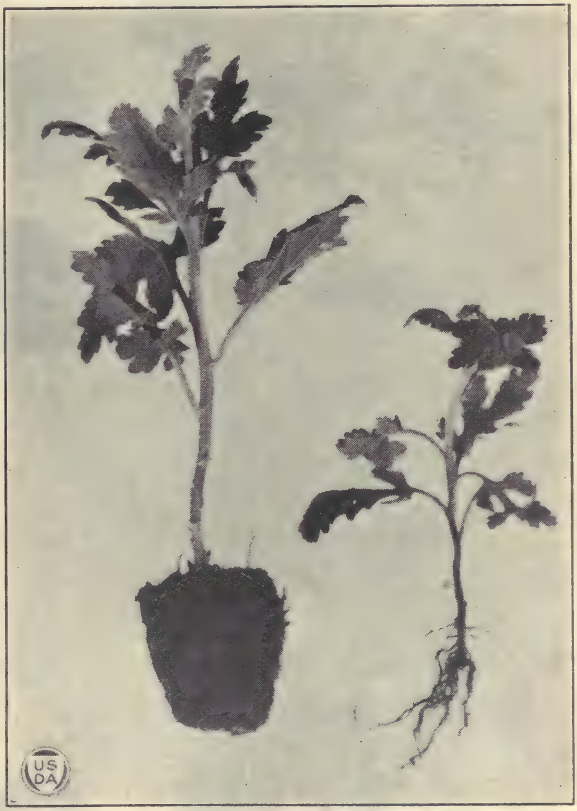

FIG. 2.—Rooted cuttings of chrysanthemum.

PREPARATION OF THE SOIL.

If the plants can be given a bed to themselves or grown on the edge of the vegetable garden, the results will be even better than in a mixed border. Choose preferably a position in full sun with a soil that is light, rich, and above all well drained, especially if the plants are to be left in the ground over winter. If the planting is a large one, an abundant supply of manure should be forked into the soil; if the bed is small, a good method is to work a shovelful of manure into the spot where each plant is to be set. The value of sufficient fertilizer can not be overemphasized in the growth of the chrysanthemum, for it is a plant which must not be checked by lack of food or moisture in its development to flowering.

SUMMER PRUNING OR STOPPING.

Almost as soon as the plant shows signs of becoming established in the new position, the growing tip should be removed, to induce branching. Generally, it is advisable to pinch out the top of the shoot after three or four pairs of leaves have formed, but in the writer's garden experience even better results may be had by removing the tip after the second pair of leaves is mature. Three to five shoots will appear, which, in turn, should be stopped, to induce branching.

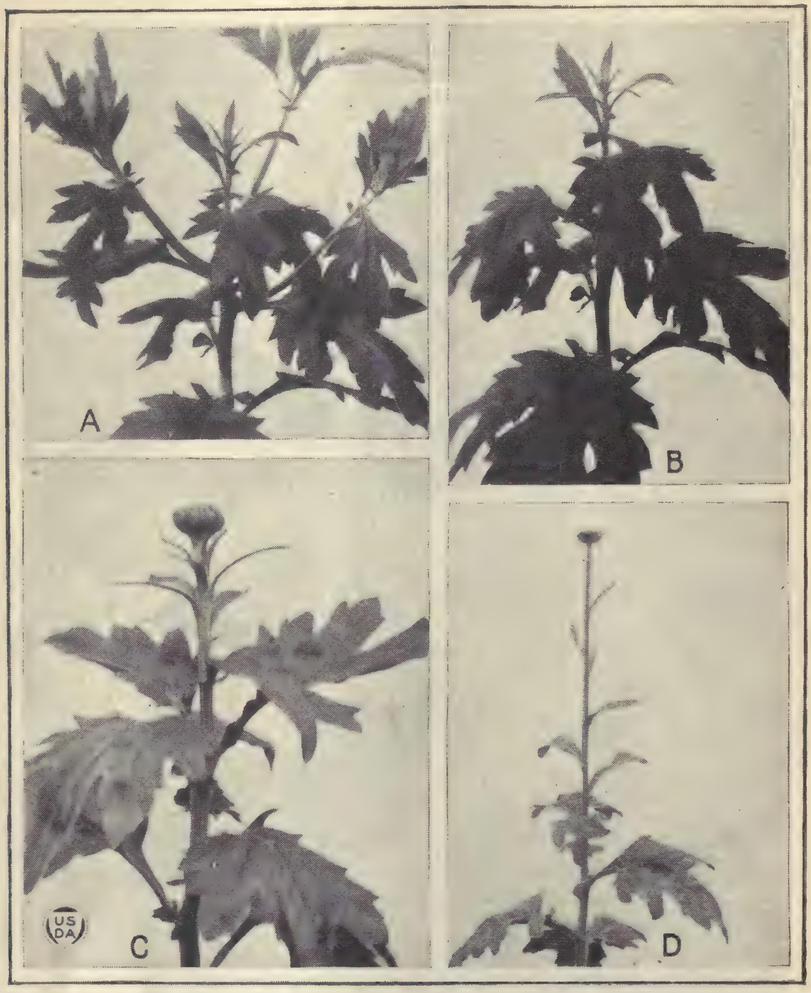

FIG. 3.—Development of the crown bud: *A*, Crown bud, with secondary shoots formed; *B*, the same, with side shoots removed; *C*, the same, with three weeks' growth; *D*, later development of crown bud in another variety, showing the long leafless neck below the bud.

The importance of this can not be overestimated. Only too often the garden chrysanthemums grown in small places are great sprawling plants, almost like shrubby climbers, which yield crooked stalks for cutting. A little experience will enable one to decide the best number of stoppings for each variety, as some branch freely with one or two stoppings, while others must be checked repeatedly. No pinching out should be done after the middle of July, as this might bring the bloom too far into the autumn. Under this treatment plants will usually form broad, spreading bushes with erect, upright branches quite strong enough to bear the large flowers coming later.

FERTILIZING.

From about the time of the last stopping, extra feeding can be given to advantage. As midsummer is also the time of greatest heat, extra water should be given if the soil is at all likely to dry out, and the surface should be thoroughly hoed, to insure a thick mulch. The extra feeding is commonly given in liquid form, alternating liquid manure, solutions of nitrate of soda, and sulphate of ammonia. In applying these, it is better to give copious supplies of dilute fertilizer once a week rather than smaller amounts more frequently. The soil should be watered before the fertilizers are applied. This extra feeding is often omitted for the garden varieties, but usually is more than worth the trouble. In any case it should be stopped by the time the color commences to show in the flower buds.

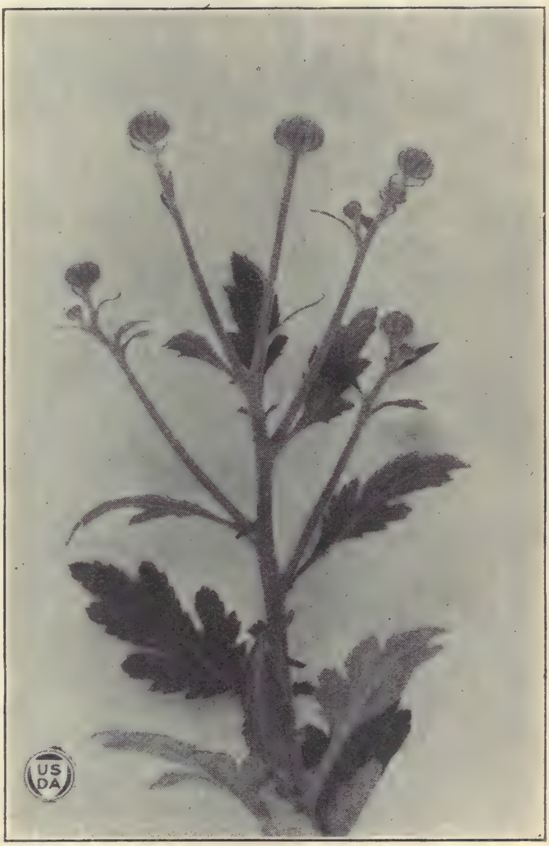

FIG. 4.—A cluster of terminal buds.

STAKING.

The period of midsummer growth is especially important after the last stopping of growth has been made, for it is during this time that stakes should be driven beside those plants which grow so tall that their stems will not support them. A safe generalization would be that stakes will be needed for all the upright kinds, like the familiar Lillian Doty, which, in spite of all stopping, will give tall, unbranched stems after midsummer. A stake early in the summer will insure the erect growth of the flowering shoots, an item of no small importance when the blooms are cut.

In the latter portion of the summer, chiefly after mid-August, the plants begin their preparations for bloom. The types of buds produced by chrysanthemums and their influence on the resulting bloom have been much studied by commercial growers. The smaller flowered sorts are less affected, but as some of the large-flowered varieties can be grown successfully in the garden, a description of these buds is necessary.

DISBUDDING.

The first bud produced by a chrysanthemum is called a "crown" bud. On the large-flowered varieties this is the bud which usually will produce the largest bloom. Almost as soon as it appears branches grow from the axils of the topmost leaves. If the crown bud is to be saved, these must be removed at once. The branches on the plants photographed and reproduced as Figure 3 were allowed to grow too long before removal, to illustrate more clearly their relation to the crown bud. When they are removed all the strength of the plant rises to the crown bud, giving it a great development. If it is not to be saved, and indeed in most of the garden varieties known to the writer it is often abortive, the shoots near it should remain. If a single flower is wanted, save but one; if many flowers are wanted, all should be kept. Each will develop and produce terminal buds in clusters of from three to six or seven. If the strongest one of these is saved, it will produce a large flower, but for garden decoration more should be saved, producing what the florists call "sprays" of bloom. (Fig. 4.)

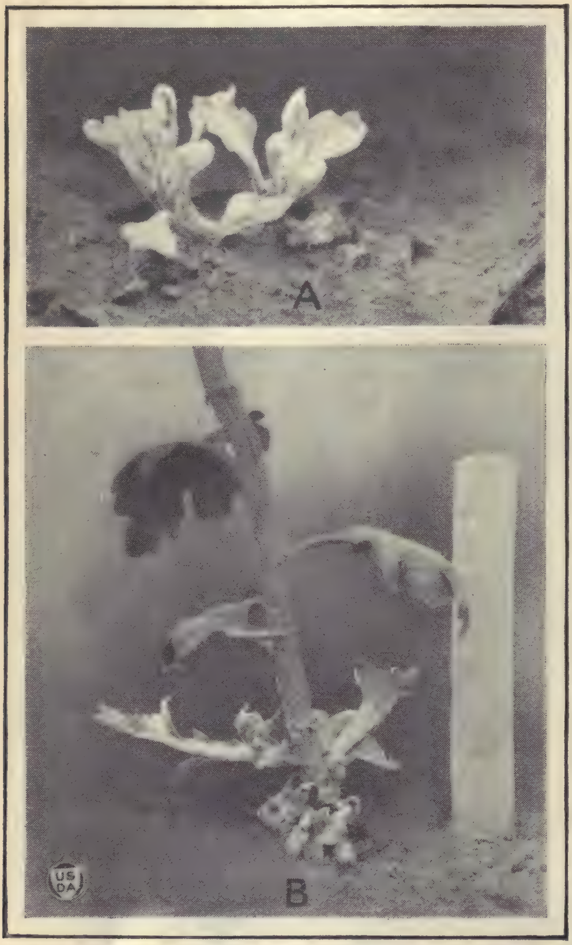

FIG. 5.—Propagating material: *A*, Good shoots arising from below the ground: *B*, poor shoots arising from the woody stem.

The desirability of disbudding varieties of hardy chrysanthemums is largely a matter of personal taste. The writer prefers not to disbud any of the outdoor plants except some of the early-flowering commercial varieties of Chinese and Japanese sorts and members of the groups known in the trade as decorative and early-flowering chrysanthemums. The former are greatly helped by disbudding, and the latter produce moderate-sized flowers of great beauty, both in the garden and for cutting. Of the first type may be mentioned Pacific Supreme, Unaka, Chrysolora, and October Frost, all of which are hardy in Washington, D. C., and of the latter the beautiful Source d'Or, Tints of Gold, and Mrs Harrison Craig.

SHELTERS.

By the time of flowering the season will have advanced until there is danger of frost. Chrysanthemum plants are quite frost hardy, but the half-open flowers, especially of white and pink varieties, are badly damaged. A certain amount of danger can be overcome by choosing portions of the garden where frosts do the least damage—i. e., where the cold air does not settle. Experience will show which varieties are most susceptible and which bloom before the first frost and between that time and the later frosts. The matter of artificial protection each person must decide for himself. Unquestionably it requires considerable labor to prepare temporary shelter of any kind. Most commonly a frame is built over the bed on which hotbed sash can be laid for roofing and the sides covered with burlap or similar material. It is to be hoped that in time a strain of early-flowering plants will be found. Those who are willing to make shelters for varieties which bloom too late to escape frosts have devised various temporary shelters of cloth or sash which give fairly adequate protection.

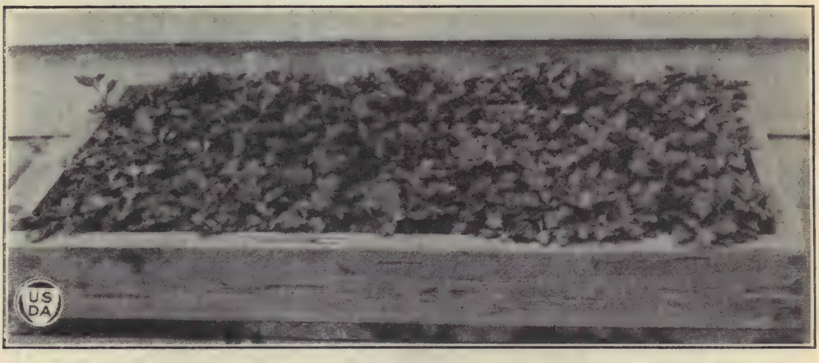

FIG. 6.—Young chrysanthemum plants grown from seed.

If the plants are grown in the ground, a tent or houselike shelter is built over the bed at such a height as to clear the stems. It should be made strong enough to carry the weight of the covering, and the framework should have the roof supports spaced sufficiently close together to prevent the covering cloth from sagging when wet by rain. In the far South this covering is often a firmly woven cheesecloth or muslin, but farther north it is usually of some heavier material. Whatever the material and however carefully the framework is constructed, this type of shelter is open to some criticism, in that dust and soot gather on the cloth and are worked through when it rains, spoiling the flowers beneath.

This difficulty is removed if the cloth on the roofs of these shelters can be replaced by coldframe sash with cloth sides which are rolled up during the day.

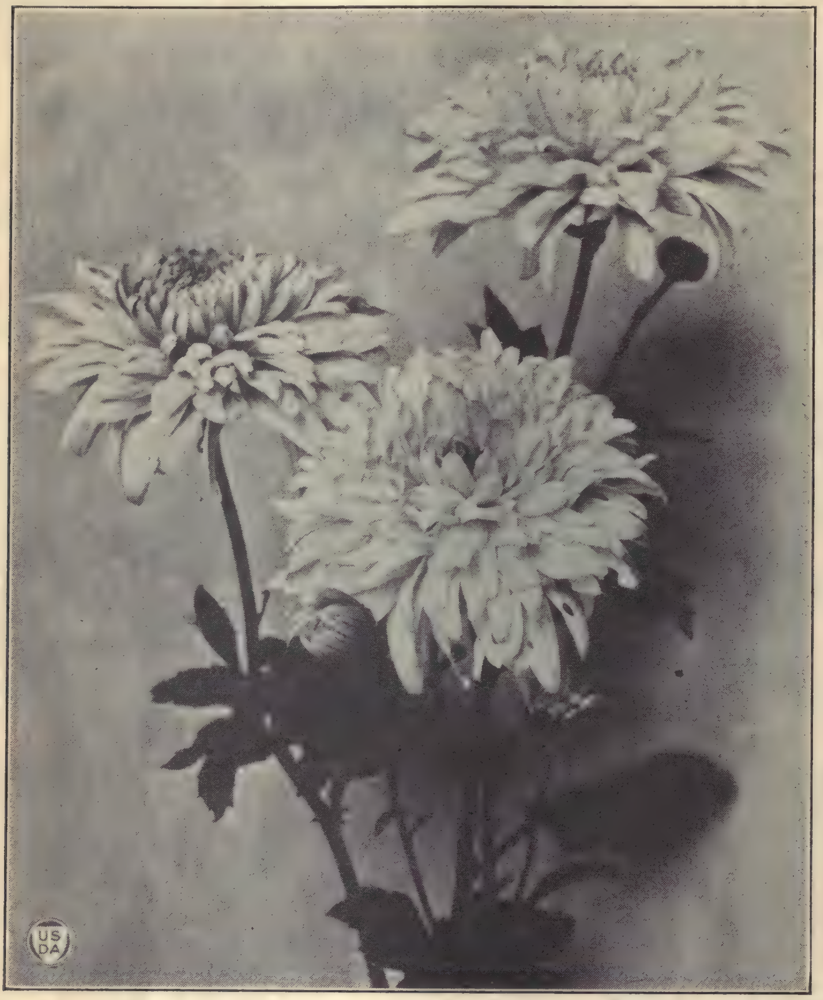

FIG. 7.—Pacific Supreme, an exhibition variety of chrysanthemum, partially disbudded and grown in the garden.

Sometimes it is possible to provide awninglike shelters of cloth from the side of a building. These, of course, are rarely beautiful, and the plants beneath become rather one-sided, as the light does not reach them from all sides.

A thoroughly satisfactory method sometimes used for small collections is to grow the plants in pots set in the open until danger of frost occurs. These pots are then set in a coldframe reserved for them in which the sash has been raised on corner supports sufficiently high to admit the chrysanthemums. As the colder weather sets in, side curtains of burlap are added. After flowering the stalks are cut, the corner posts removed, and the roots wintered in the coldframe.

PROPAGATION.

In the garden, after the flowers are past, the stalks should be cut down and either one of two procedures followed. If the garden soil is not warm and thoroughly well drained the plants should be lifted and stored closely together in a cold but frost-proof frame; but if the soil is thoroughly drained they can well be left in place until spring.

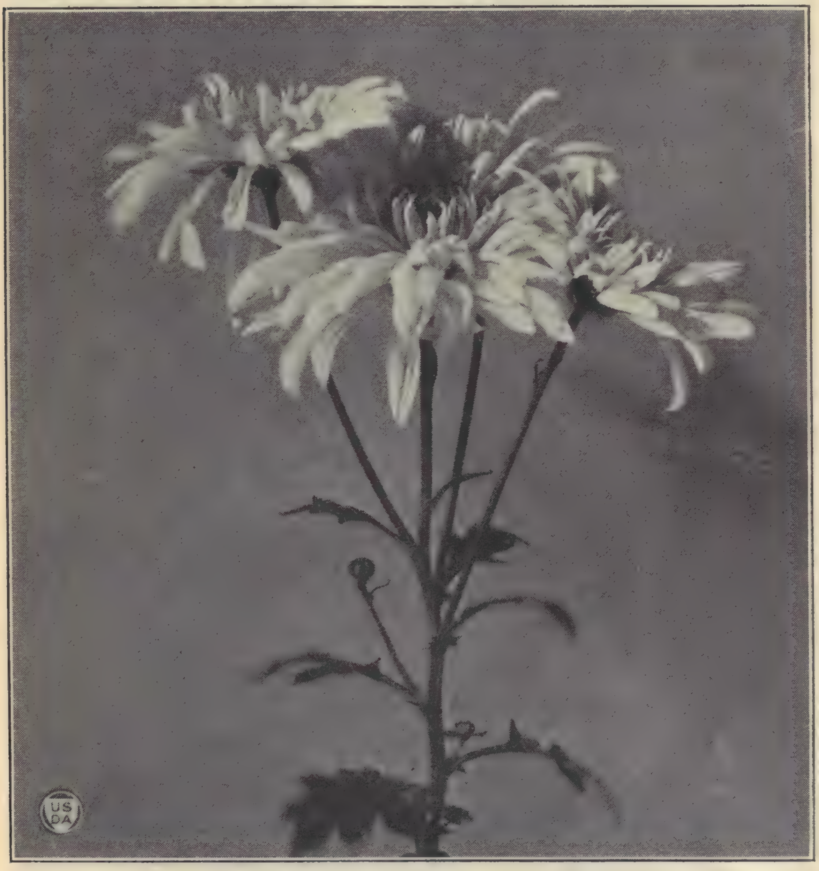

FIG. 8.—Irma, a decorative type of chrysanthemum.

The commercial grower of plants for sale commonly chooses the former method and brings his plants into a cool house in December or January to start them into growth. The little shoots (fig. 5) which form about the crown of the plant, both from underground shoots and from the old stalks, are cut off, rooted in sand, and potted off in soil, to spend the intervening months in a cold house till time for outdoor work.

The home gardener should wait till natural growth starts in the spring. Nearly all the varieties grown by the writer have suckered freely about the base, so that the clump can be lifted with a digging fork and torn into as many pieces as there are shoots. Some of these will have roots attached, but all will form roots if replanted separately in sandy soil and watered carefully for a time; in fact, it is better to cut off the end of the shoot just below the leaves and root it as a cutting in sand. This will make a plant more firmly rooted than if the underground stem had been kept. Furthermore, new shoots will arise from the cut which, in turn, can be removed to make more plants. Caution should be used in selecting cuttings, for while those

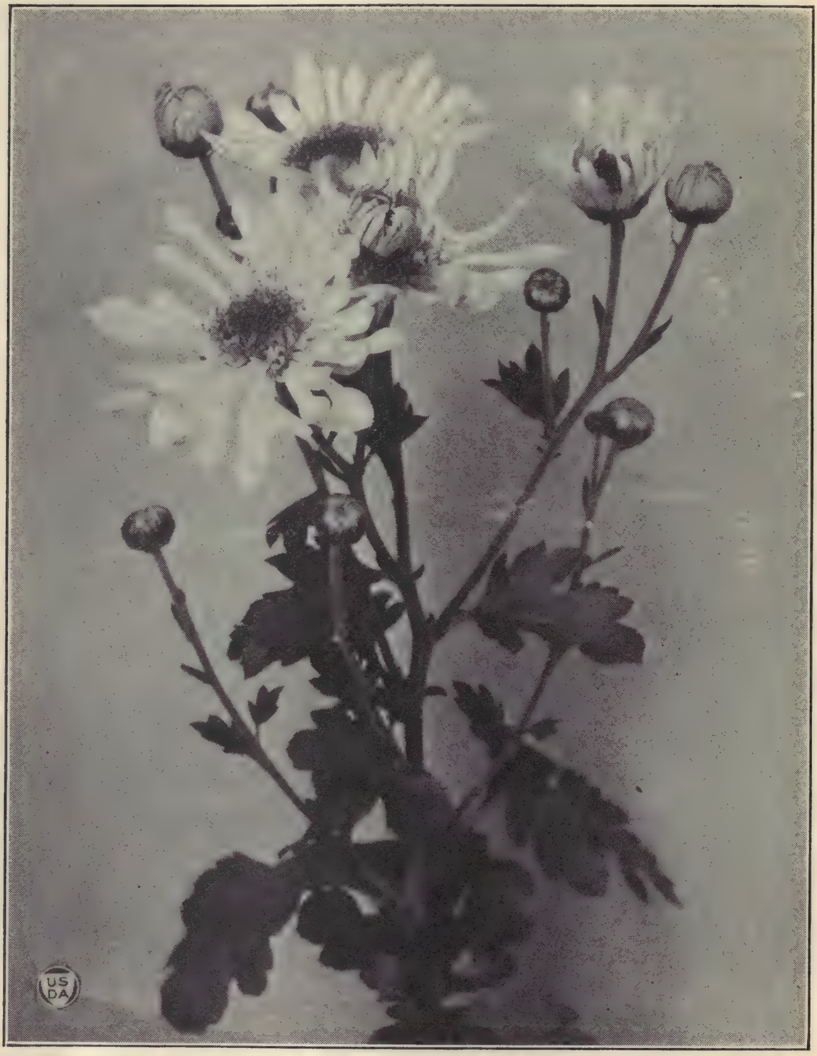

FIG. 9.—Garza, an anemone-flowered chrysanthemum.

from the more woody shoots of the old flower stalks root, as do the others, they do not develop into as good plants, though occasionally this disadvantage is offset by the fact that the resulting plants come into earlier bloom. When this bloom is over, the year's cycle of chrysanthemum culture has been completed and is begun again.

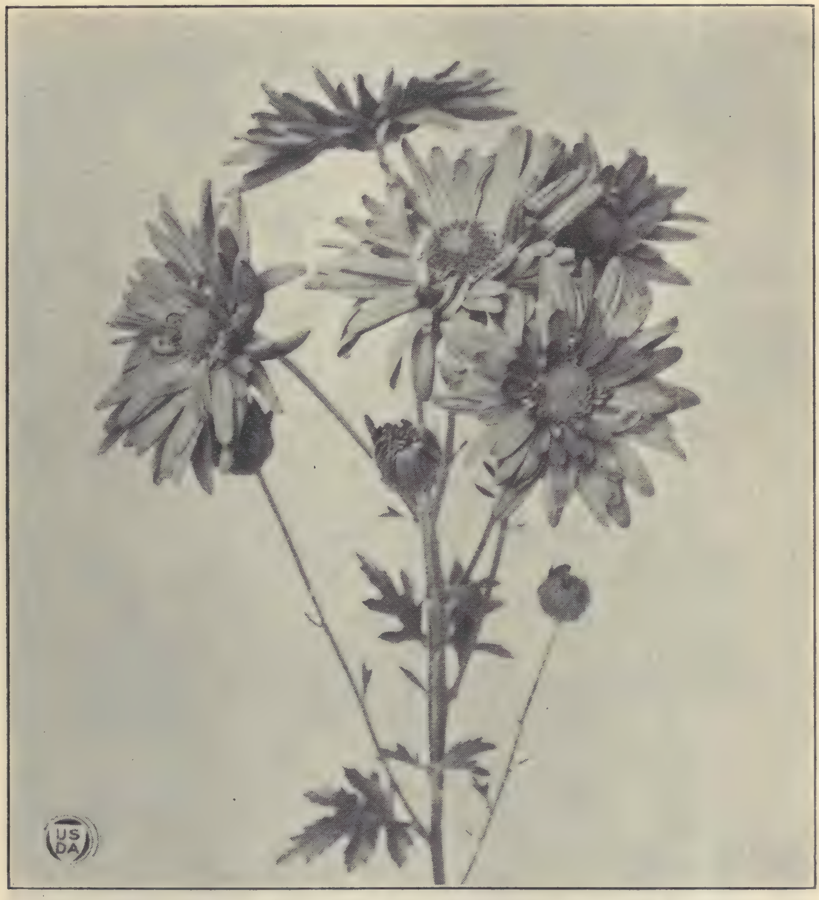

FIG. 10.—Spray of single chrysanthemums.

Seed of various types of perennial crysanthemums is offered by nearly all dealers. This should be sown indoors in carefully prepared soil about six weeks before the last frost. The seeds germinate freely and should be grown without check in a cool temperature to prevent damping-off and to induce sturdy growth. The individual plants should be potted as soon as possible and planted out when the weather permits. The accompanying illustration (fig. 6) shows a box of small seedlings. If carefully grown, seedlings should flower the first year from seed, but a second season will be needed to determine their full value.

Occasionally self-sown seedlings appear in the garden clumps. As they rarely come true to color, their appearance can usually be detected at once. They should be removed immediately and destroyed if of undesirable color. It is the appearance of such seedlings that leads to the stories of chrysanthemums reverting which are sometimes heard. If these seedlings are not removed, they often succeed by their great vigor in crowding out the original plants.

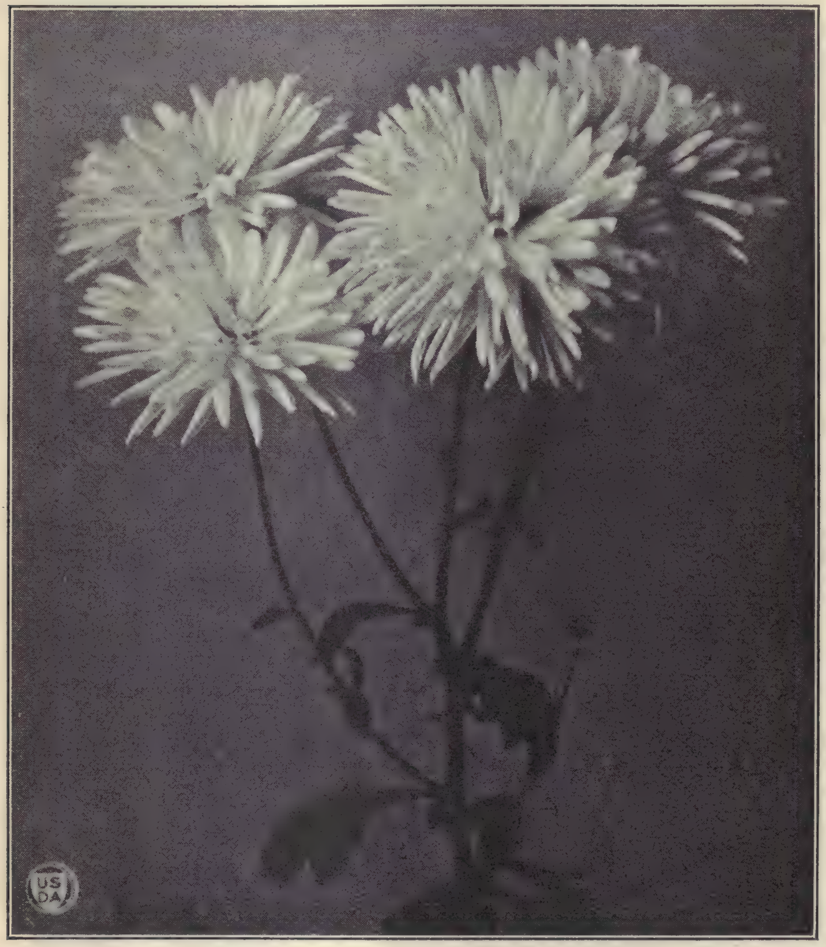

FIG. 11.—Virginia Seymour, a large-flowered pompon.

VARIETIES.

The choice of varieties for the garden is a difficult matter, because each person has a personal preference to be considered. In addition, the chrysanthemum, having become a flower of the specialist, is exhibited in dozens of new forms each year, some of which survive the test of distribution, while others are dropped after one season, thus making the chosen list of any date more or less useless after a very few seasons.

TYPES OF BLOOMS.

Certain types of blooms should be known to all growers and gardeners, the final choice of varieties from these being safely left to the individual.

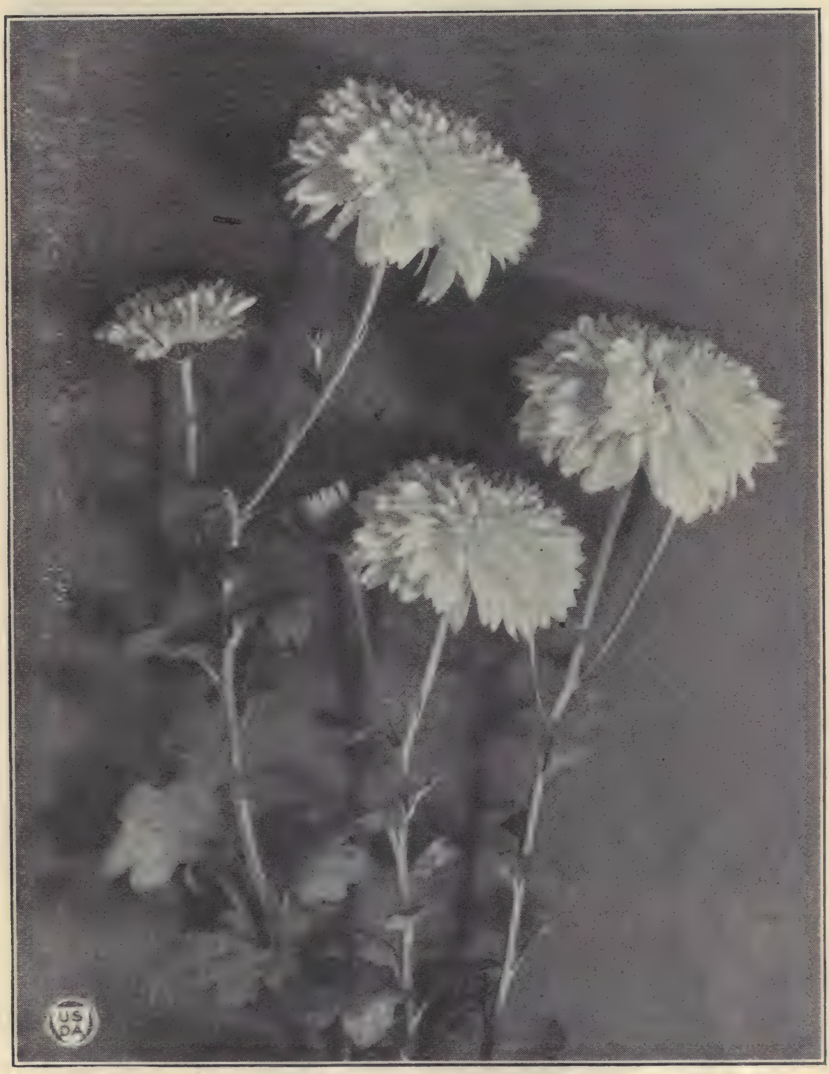

FIG. 12.—A pompon intermediate between the pompons and the aster-flowered types of chrysanthemum.

The large-flowering varieties which came originally from China and Japan do not figure extensively in the hardy garden, except in the extreme South. From Washington, D. C., southward some of the earliest of the commercial sorts can be raised out of doors. In looking through the growers' lists, note the dates of flowering and for the Northern and Middle States choose the varieties which mature by or before the middle of October. In the South proportionately later flowering varieties will be satisfactory. These, with some shelter for the blooms, can be flowered to a very considerable degree of perfection. In all the classes of chrysanthemums the colors range from white through lemon yellow to orange, bronze to chestnut reds, and from white through flesh and rose to deep amaranth reds and purples. Often there are combinations of two colors in one flower, as in Earl Kitchener, amaranth with a silver-pink reverse, or Mrs. Ernest Wild, chestnut red with bronze reverse. The shapes of these flowers also show great variety, from the incurved forms, in

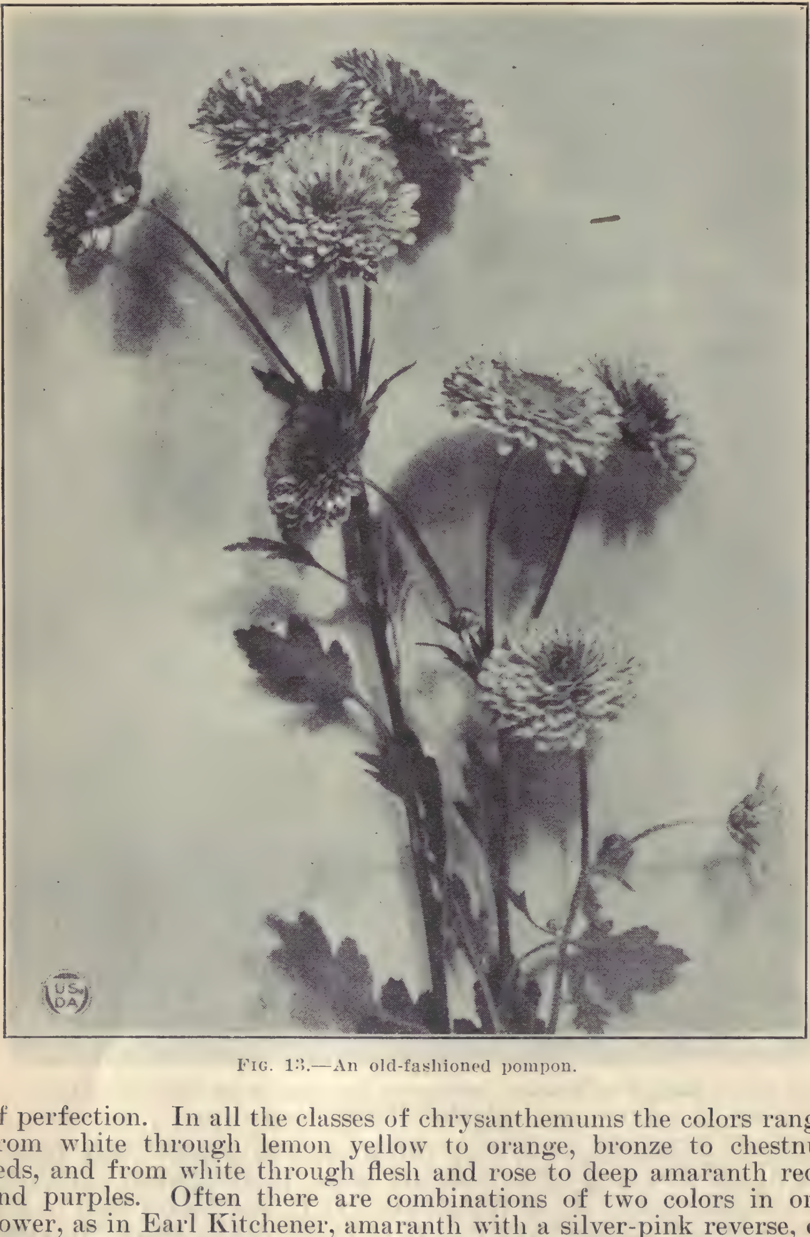

FIG. 13.—An old-fashioned pompon.

which every petal folds regularly inward, through the reflexed varieties, with petals falling away from the center, to Japanese forms in which the petals twist about in various fantastic ways.

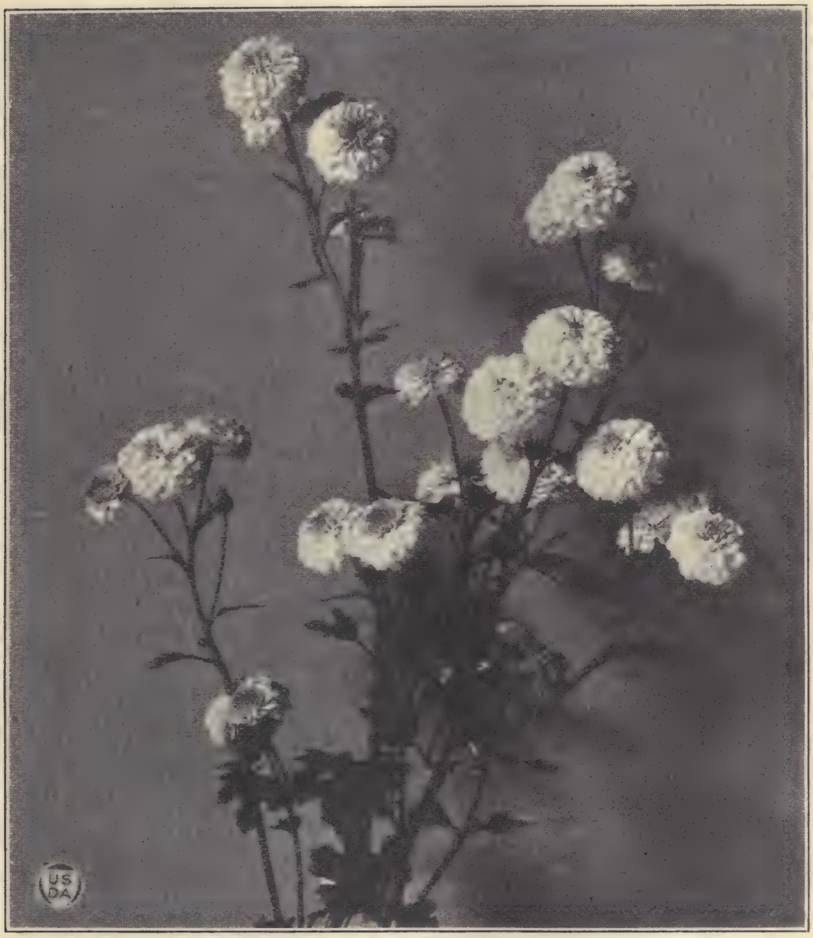

FIG. 14.—Nio, a button-flowered pompon.

The early-flowering and decorative varieties (figs. 7 and 8) are not so much grown by amateur gardeners as they well might be. They flower as freely as the pompon varieties and produce blooms of considerable size and a delightful range of shapes and colors. The accompanying illustrations show better than words the sorts of flowers to be had.

With the early-flowering sorts should be grown some of the anemone-flowered varieties. (Fig. 9.) They are delightful chrysanthemums, much like single or semidouble ones, except that the florets of the yellow disks have lost their color and develop a more petal-like substance. All are likely to be rather late flowering and should be given a sheltered location.

The single varieties (fig. 10) have come into a tardy popularity, possibly because they do not stand shipment as well as some others and consequently have not attracted commercial attention. They are, however, beautiful flowers for the home gardener and in the opinion of the writer are the very best sorts for cut flowers for the home as well as for garden decorations. Their number is legion, and the variations of color, form, and degree of singleness are so many that an extensive collection might well include only single sorts.

The pompon chrysanthemums (figs. 11 to 14) have two marked extremes of form, the so-called aster-flowered types, such as Mrs. Frances H. Bergen, and the little buttonlike forms, such as Baby or Nio. The gradation between the two is very gradual, and many forms appear. Personally, the writer prefers the smaller flowered forms, like Nio, Golden Climax, Julia Lagrevere, and Queen of the Whites, to other forms. Some of the larger aster-flowered types respond to disbudding, but unless they are of a rather flat type of flower, like the Lucifer, the resulting bloom is too fat and puffy to suit some tastes. This is especially true of the popular Lillian Doty and its white counterpart.

INSECT ENEMIES.

No discussion is included in these pages of the insect enemies affecting the chrysanthemums, since they are fully treated in Farmes' Bulletin 1306, Insect Enemies of Chrysanthemums. The remedies described in it are those best suited for use in the home garden. Copies of this bulletin may be obtained free upon application to the Department of Agriculture, Washington, D. C.

By way of emphasis, however, it may be noted that the aphis in its several forms, black, green, and red, finds the chrysanthemum a favorite feeding place, and the careful gardener must be constantly prepared to apply tobacco sprays to prevent the aphids from multiplying to such numbers that the plants are checked in their development. Two thorough sprayings will check each attack, one killing the larger part of the infestation and the second catching any which escaped the first application.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1312

TREE PLANTING in the GREAT PLAINS REGION

IN THE TREELESS Great Plains Region, trees and shrubs are essential to the making of a real home. The first step in forest planting should be to provide a windbreak or shelter belt to afford protection from the winds. Then a woodlot should be started for the production of fence posts and fuel.

Only proven hardy species should be chosen for planting. A number of trees can be grown successfully and will greatly enhance the value of the farm.

A large proportion of the failures in plantations is caused by the negligence of planters.

Thorough preparation of the soil, spring planting, and thorough cultivation of the soil after planting are the essential requisites for success.

Protection should be afforded against cattle, rodents, insects, and fires.

Washington, D. C. April, 1923.

TREE PLANTING IN THE GREAT PLAINS REGION.

By FRED R. JOHNSON, *Forest Examiner, Forest Service,* and F. E. COBB, *Assistant in Dry-Land Arboriculture, Bureau of Plant Industry.*

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OBJECTS OF PLANTING.

TREES AND SHRUBS are essential to the making of a real home. They increase the value of the property and make conditions more pleasant and healthful. There is scant comfort in a house or barnyard exposed to the chilling winds and drifting snows of winter and the withering blasts of a hot, dry wind in summer.

The absence of tree growth has been a hindrance to the most rapid development of the region known as the Great Plains. Many of the early settlers, tired of the struggle against rigorous climatic conditions, have sold out and departed; but those who have remained, together with the more permanent farmers who always follow the first settlers, are gradually developing their farmsteads as homes. Substantial frame houses and improvements are slowly replacing the "soddies" and "dugouts" of the early days. The building of good roads, the general use of the automobile, and the insistence of farm wives and children upon some of the modern conveniences are causing many farmers to realize the necessity of having real homes.

On the average farm in the Plains region the first step in planting should be to provide a windbreak or shelter belt, which will afford protection from severe winds and furnish shade and comfort to both man and beast. To be effective, the shelter belt must be dense,

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NOTE.—Acknowledgment is made of suggestions and advice in the preparation of this bulletin from E. F. Chilcott, superintendent, Woodward Field Station, Woodward, Okla.; Beyer Aune, superintendent, Bellefourche Experiment Station, Newell, S. Dak.; W. J. Morrill, State forester of Colorado, Fort Collins, Colo.; W. P. Snyder, superintendent, State Experiment Station, North Platte, Nebr.; R. J. Pool, professor of botany, University of Nebraska, Lincoln, Nebr.; Jay Higgins, forest supervisor, Halsey, Nebr.; and H. C. Hilton, forest supervisor, Laramie, Wyo.

and the farmer must not expect to secure any great amount of wood from it for farm use, as removing much large material or even trimming the branches may lessen or even destroy the protective value of the windbreak.

In addition to the shelter belt for the protection of the farm buildings, garden, orchard, and stock-feeding yards, every farm should have a wood lot for raising fuel, posts, and perhaps a limited amount of poles and saw-log material. The high price of coal and the low value of farm products at times have caused many farmers in portions of the Great Plains, especially those situated a considerable distance from the railroad, to burn corn. During periods of hard times some have been obliged to use cow chips for fuel as the early settlers used buffalo chips. (Fig. 1.) The continuation of these practices is for the most part unnecessary, since the comparative ease with which poplars or other fast-growing species can be grown in much of the region makes it possible for farmers to have a supply of wood for fuel. (Fig. 2.) If good care is given the trees, they will develop rapidly. Some will have to be cut out to prevent harmful crowding. The material thus removed will furnish posts and fuel. When the plantation is still older, larger and more valuable products may be harvested, such as small telephone poles for farmers' lines, small timbers, and miscellaneous material for general use around the farm.

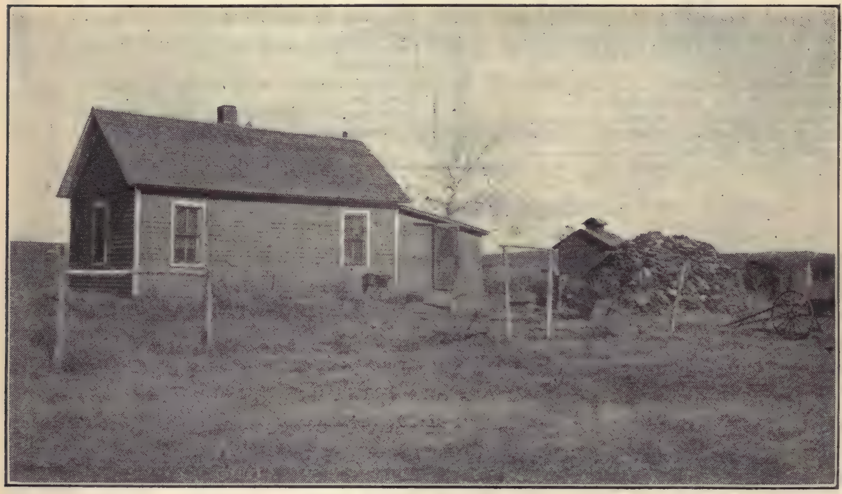

FIG. 1.—Ranch house in western Nebraska. No comfort; cow chips for fuel.

THE GREAT PLAINS.

The Great Plains extend from about the 99th meridian west to the foothills of the Rocky Mountains. They include roughly the western half of North and South Dakota, Nebraska, Kansas, Oklahoma; the "panhandle" of Texas as far south as the southern line of New Mexico; and the eastern Plains region of Montana, Wyoming, Colorado, and New Mexico. (Fig. 3.) This embraces approximately

400,000 square miles, or a territory equal to all of New England and the Atlantic Coast States, including Florida. The elevation of the Great Plains varies from 1,300 feet above sea level on the Missouri River in South Dakota to about 7,000 feet in southeastern Wyoming and on the Arkansas divide in Colorado.

CLIMATE.

The climate is characterized by a light rainfall and a comparatively high wind velocity with its accompanying high rate of evaporation. Wind, in fact, is the limiting factor in tree growth in the higher portions of the Plains, particularly in southeastern Wyoming. The northern Plains are subject to extremes of temperature both in summer and winter, and hail storms are common throughout the region. Taken altogether, the climate is so very difficult that trees can be raised on dry-land sites only with special care.

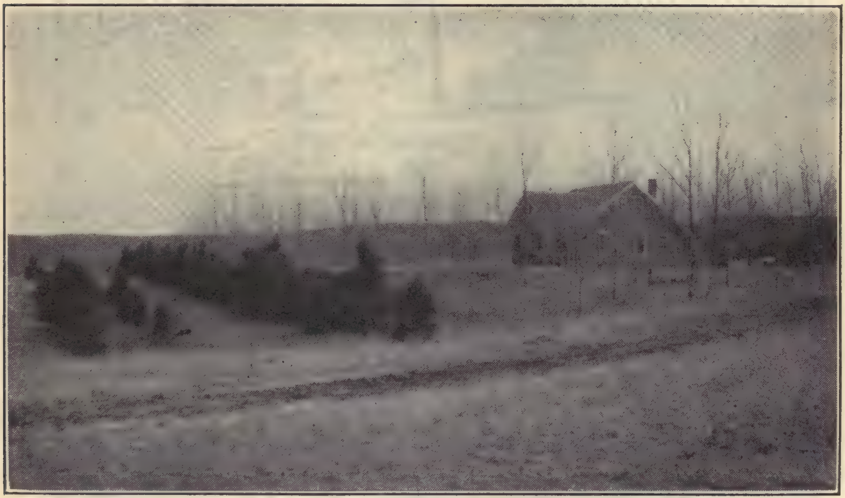

FIG. 2.—Carolina poplar and western yellow pine planted. Thomas County, Nebr. Comfort arrived; wood for fuel on the way.

SOILS.

The types of soil that characterize this area range from pure sand in the sand hills of Nebraska, through sandy loam, loess, silt, and clay loam to heavy gumbo clay and shales. In some sections an impervious layer of cemented gravel or heavy clay a few feet beneath the surface prevents the ready passage of soil moisture to or from the lower depths. This, of course, would limit the root system of the tree to the upper levels of the soil and make it dependent almost wholly on rainfall for water. There are also some localities where alkaline salts are present in the soil to such an extent as to prevent the growth of trees.

SECTIONS.

For the planting of trees, this region may be divided into the northern, central, and southern Great Plains. The northern Great Plains includes roughly the western parts of North and South

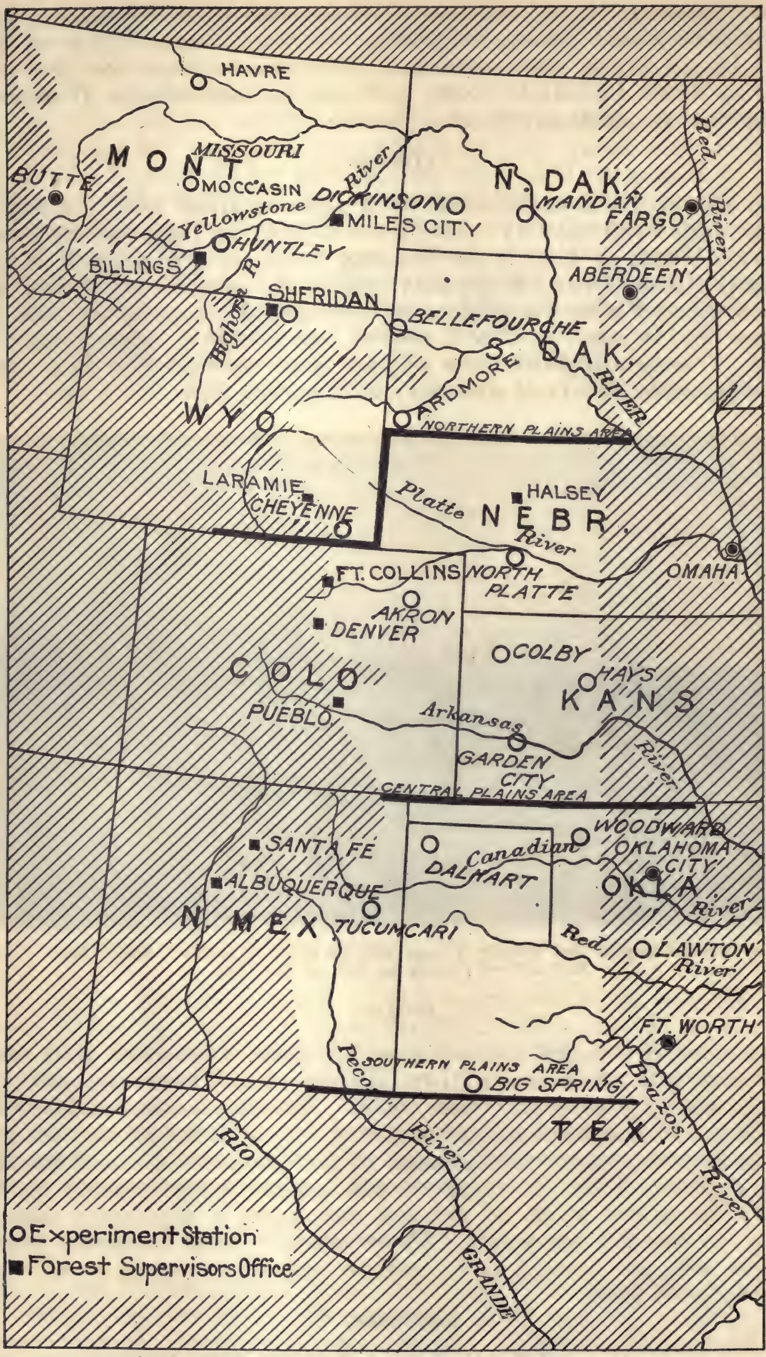

FIG. 3.—Sketch map of Great Plains.

Dakota and the plains sections of Montana and Wyoming. The central Great Plains includes western Nebraska and Kansas and eastern Colorado. The southern Great Plains comprises western Oklahoma, western Texas to the southern boundary of New Mexico and eastern New Mexico.

SPECIES RECOMMENDED.

The trees adapted to these sections are presented in two groups in the approximate order of their desirability—those which are actually known to be hardy and those which are semihardy in certain districts or entirely hardy under irrigation. Of course it is not possible thus arbitrarily to divide the region by definite lines, as the range of any desirable tree overlaps from one section to the other.

HARDY TREES.

A list of hardwoods and conifers follows:

Northern Great Plains. (Western North and South Dakota, eastern Montana, and Wyoming.)	Central Great Plains. (Western Nebraska and Kansas, eastern Colorado.)	Southern Great Plains. (Western Oklahoma and Texas, eastern New Mexico.)
Hardwoods: Green ash. Box elder. American elm. Northwest poplar. Caragana (Siberian pea). Russian olive. Buffalo berry. Chokecherry. Wild plum. Conifers: Black Hills spruce. Jack pine. Colorado blue spruce. Red cedar. Western yellow pine (bull pine). Scotch pine.	Hardwoods: American elm. Honey locust. Hackberry. Green ash. Russian olive. Cottonwood (common and lance-leaf). Poplar (Norway and Carolina). Chinese elm. Buffalo berry. Willows (laurel-leaf, Russian golden, white). Box elder. Osage orange. Russian mulberry. Chokecherry. Wild plum. Caragana. Black walnut. Conifers: Jack pine. Western yellow pine. Scotch pine. Black Hills spruce. Red cedar. Chinese arborvitæ. Colorado blue spruce.	Hardwoods: Russian mulberry. American elm. Honey locust. Green ash. Russian olive. Cottonwood. Osage orange. Hackberry. Black walnut. Caragana. Chinese elm. Soapberry. Conifers: Chinese aborvitæ. Red cedar. Scotch pine.

A further grouping of the hardy trees shows the uses to which they are best adapted. Most of the species listed are suitable for windbreaks, but many of them will not produce poles or lumber. The ideal shelter belt will contain a mixture of species, with the low-branching, compact species on the windward side and the larger and usually longer-lived trees on the lee.

The low-branching, compact species most suitable for windbreaks are Caragana (Siberian pea tree), Russian olive, buffalo berry, Russian mulberry, wild plum, and chokecherry. Most of the conifers listed, and particularly red cedar, Black Hills spruce, and Chinese arborvitæ, make very effective windbreaks.

For posts and small telephone poles, green ash, American elm, honey locust, osage orange, red cedar, jack pine, Scotch pine, and western yellow pine are suggested, but when used for these purposes, a preservative treatment with creosote is advisable for all these species except osage orange and red cedar.

Any of the species can be used for fuel. Box elder is usually of such poor form that it is not suitable for any other purpose.

Of the species adapted to the Great Plains, cottonwood, American elm, western yellow pine, and Scotch pine will make the best lumber.

SEMIHARDY TREES.

In the Great Plains region there are many trees that are hardy in certain sections but are of no value in others. There are also trees that are hardy on the eastern edge of the region that have been planted but little, if any, in the more severe regions farther west. These are listed in the following paragraph, and it would be well to try them out, at least in towns where plenty of water is available or on irrigated projects.

In the northern Great Plains (North Dakota, Montana, and northern South Dakota), linden or basswood, black walnut, Chinese elm, lance-leaf cottonwood, and Tartarian maple; in southern South Dakota, honey locust, hackberry, Russian mulberry, white willow, Russian golden willow, laurel-leaf willow, and soft maple. In the central Great Plains, the foregoing willows, osage orange, soft maple, Kentucky coffee tree, catalpa, sycamore, and white ash. In the southern Great Plains, catalpa, sycamore, ailanthus, Arizona ash, Arizona cypress, and New Mexico locust.

TREE DESCRIPTIONS.

A description of the more important species follows:

HARDWOODS.

Green ash (*Fraxinus lanceolata* Borkh.).—The green ash is found over practically the entire Great Plains, growing naturally on upper levels of the valleys and often pushing far up open valleys or ravines to the prairie levels. It grows very well under cultivation and is one of the most desirable trees for either shelter belts or woodlots. (Fig. 4.) It responds well to good treatment; in fact its value as a producer of useful material is largely dependent upon the care given it. In sections where it is attacked by a borer, it should be grown in mixture with some other species. It grows well on nearly all kinds of soil except sand and gravel and those soils that are heavily alkaline. In valleys, under most favorable conditions, it may grow an inch in diameter in two years; but in neglected upland groves it sometimes requires nine years to make that much growth. In plantations at North Platte, Nebr., green ash has attained an average height of 20 feet in 15 years.

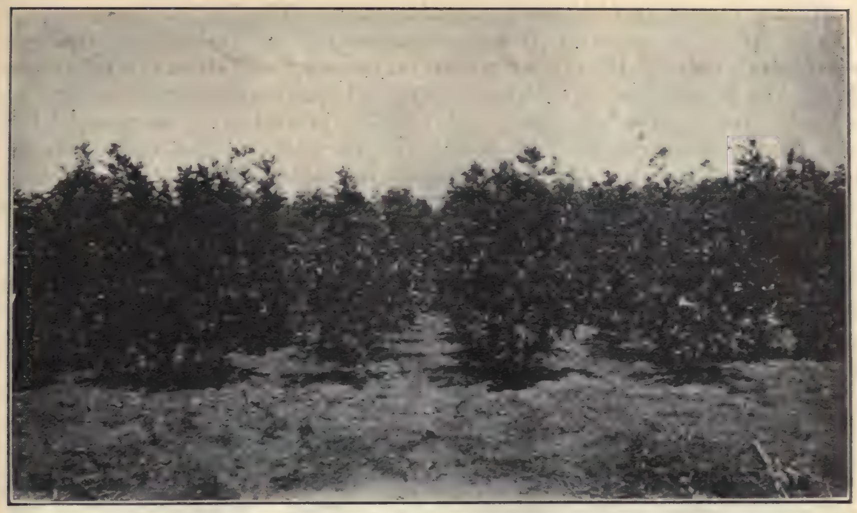

FIG. 4.—Green ash plantation 4 years old. Ardmore, S. Dak.

American or white elm (*Ulmus americana* L.).—The American elm is native to the Great Plains except in central Montana, Wyoming, Colorado, New Mexico, and western Texas. (Fig. 5.) It is, however, hardy to the foothills of the Rocky Mountains and is one of the best trees for shelter belts, woodlots, and street plantings on either upland or bottom sites, on dry or irrigated land. American elm thrives best in a heavy soil, but adapts itself fairly well to a sandy loam. Owing to its early flowering and seeding habit, the flowers or seeds are frequently killed by late frosts, and this often makes it impossible for several years in succession to secure local seed on the Plains.

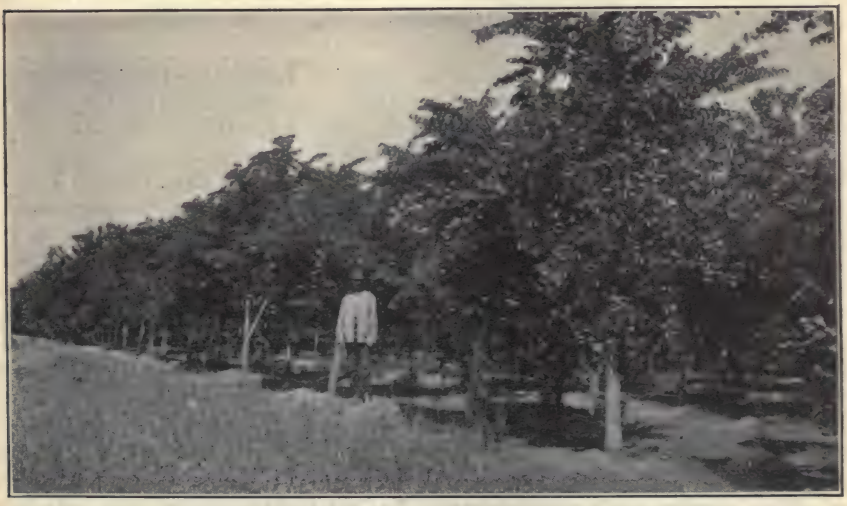

FIG. 5.—White elm plantation 9 years old. North Platte, Nebr.

Honey locust (*Gleditsia triacanthos* L.).—The honey locust ordinarily may be planted from southern South Dakota southward through the Great Plains, although on exposed situations in northern Nebraska it occasionally freezes back. It has made a good record as a hardy, rapid-growing, general-purpose tree and is recommended for planting in that region. (Fig. 6.) It has rather light, open foliage and in shelter-belt plantings should be mixed with more densely foliaged trees. A large proportion of the trees have good form, and they are strong in stem and branch and not often injured by wind or ice storms. The tree is well adapted to heavy soils on uplands as well as on bottom lands and irrigated sections. Its rate of growth is only moderate, but is maintained for many years. Honey locust planted on an upland situation in northwestern Kansas has reached a diameter of 5.7 inches and a height of 24 feet in 20 years.

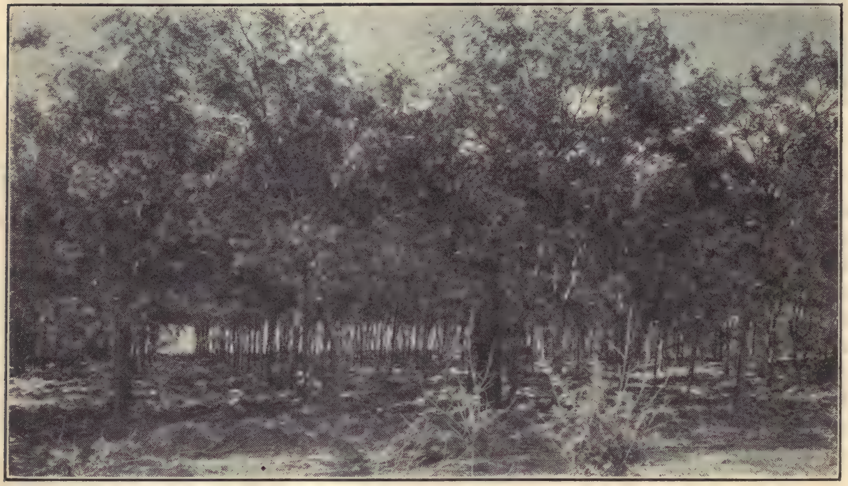

FIG. 6.—Honey locust plantation 9 years old. North Platte, Nebr.

Russian mulberry (*Morus alba tatarica* Loud.).—This mulberry has proved to be of greater value than the native varieties of the more central and southern States. On upland sites it has proved to be hardy as far north as southern South Dakota and to make excellent growth as a hedgerow or windbreak. Since this tree is somewhat variable as to hardiness, only proved hardy planting stock, preferably from locations north of those where the planting is to be made, should be used. Mulberry hedges and shelter belts are common in the central and southern Great Plains. (Fig. 7.) The tree is particularly desirable for planting around an orchard, as the birds will not bother fruit trees if they can feed on mulberries. The leading shoots frequently winterkill for a foot or two, and this increases the natural tendency of the tree toward a low, bushy growth. It branches diffusely near the ground, and only severe pruning can make it develop a respectable trunk. When well developed it makes good fence posts. An 18-year-old Russian mulberry hedge in southwestern Kansas will yield nearly 200 posts from a section 400 feet long.

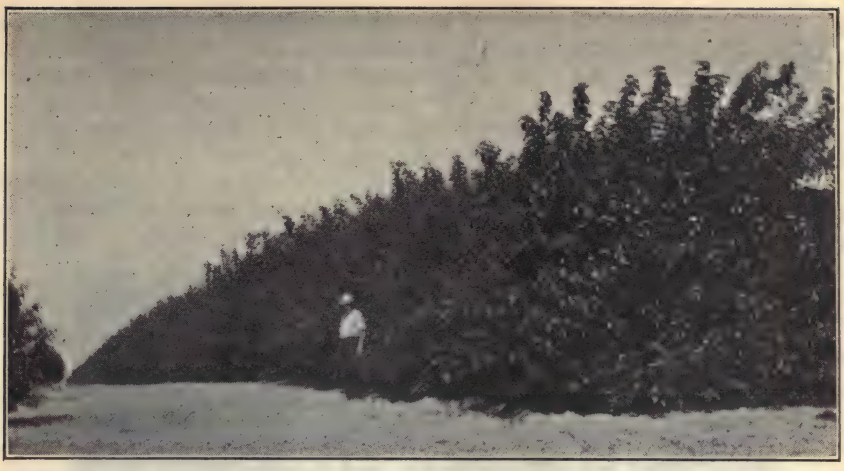

FIG. 7.—Russian mulberry windbreak 6 years old. Woodward, Woodward County, Okla.

Hackberry (*Celtis occidentalis* L.).—The range of the hackberry includes the eastern Dakotas, and extends through Nebraska to Colorado, and southeast to the Panhandle of Texas. It has not proved entirely hardy in the northern Plains and is not recommended for plantings there. In general appearance it resembles the elm and would serve the same purpose in shelter belt, woodlot, or town plantings. It may be planted on both sandy and heavy soils and also on bottom lands. Grown in combination with American elm at the North Platte (Nebr.) Experiment Station it equals the elm in height at the end of 16 years.

Box elder (*Acer negundo* L.).—This tree, also called ash-leaved maple and Manitoba maple, is without doubt the hardiest of the maples, growing in valleys to the Rocky Mountains. Because of its low-branching habit it is planted in great quantities throughout the northern and central plains for shelter-belt purposes. (Fig. 8.) It

FIG. 8.—Norway poplar and boxelder plantation. Northern Montana.

is one of the best trees for such upland plantings, but is liable to suffer some slight injury the first winter or two after it is set out. After becoming acclimated it makes good growth. It is not to be considered as a first-class woodlot tree, although a 27-year-old plantation at Great Bend, Kans., has attained an average diameter of 7 inches and a height of 25 feet.

Caragana (*Caragana arborescens* L.).—This shrub, often called Siberian pea tree, makes its best growth in the northern Plains on more or less heavy upland soils. It does not do well in sand or gravel or in low, wet situations. No attempt should be made to train it into a tree, as its natural form is shrubby. It is ideal for hedges and as low-growing trees on the outside of shelter belts. It is also used for group plantings about buildings or on lawns. In some sections of the northern Plains it is severely attacked by blister beetles.

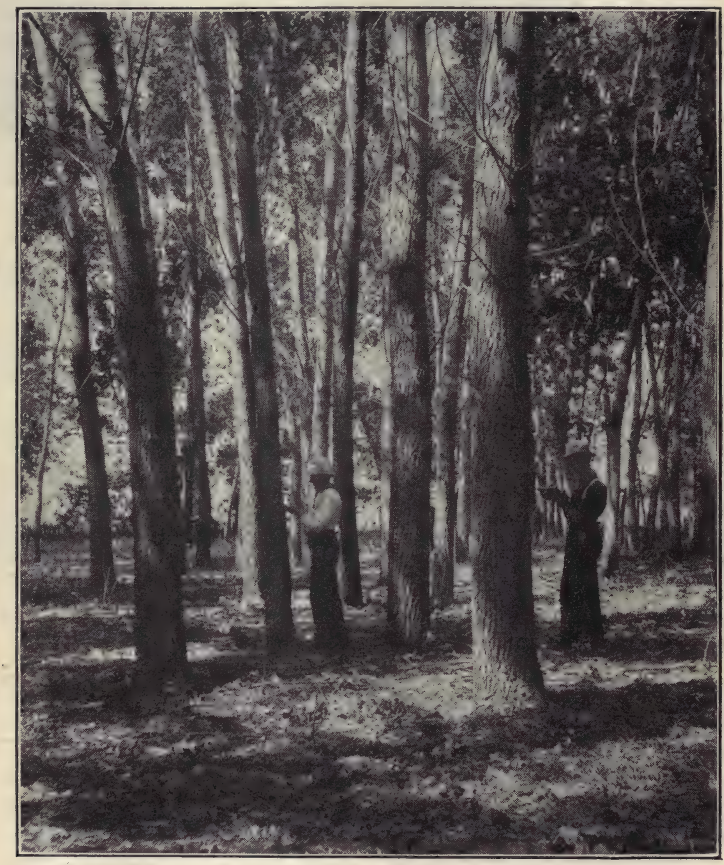

Fig. 9.—Cottonwood plantation 24 years old. Buffalo County, Nebr.

Russian olive (*Elæagnus angustifolia* L.).—The Russian olive is one of the best trees to plant for shelter-belt purposes throughout the Great Plains. It is thorny and usually bushy, although in some favorable locations it grows as high as 40 feet. When planted fairly close the trees will keep out live stock. It does well in dry land and in irrigated sections on both upland and bottom land, except in low, wet situations. It is not a woodlot tree. Its unique silver-green foliage adds wonderfully to the appearance of any combination in which it is planted.

Cottonwoods and poplars (*Populus* spp.)—Cottonwoods and poplars are fast-growing trees and are common over the entire region, though of several species and nursery varieties. (Fig. 9.) Where quick results are wanted, they are good trees to plant, provided the proper species or varieties are used. They make excellent additions to shelter belts and serve many purposes in woodlot plantings.

In the northern Plains the northwest poplar is the best to plant. (Fig. 10.) It is native to North Dakota, seems adapted to all kinds of soils, and, if well cultivated, has proved able to endure both the winter cold and the summer drought even on upland soils.

The common cottonwood will not always succeed in upland planting, but with cultivation some excellent plantations have been raised on uplands. In general, it is not recommended for dry situations. On sites favored with moisture, even at a considerable depth, it will make good growth. It has been extensively planted throughout the northern and central Plains, particularly on tree claims, and considerably in the southern Plains and the eastern parts of the northern Plains. (Fig. 11.) However, it does not do well on the uplands of the northern Plains west of the Missouri River. The nursery varieties, Norway poplar and Carolina poplar, are entirely hardy in southern South Dakota and in Nebraska. Cottonwood is short-lived, but on account of its rapid growth quickly furnishes fuel and shelter, and for these purposes it has been almost indispensable to many settlers. On sandy loam soil in southwestern Kansas, cottonwood has attained in 28 years a diameter of 18 inches at 4 feet from the ground and a height of 70 feet.

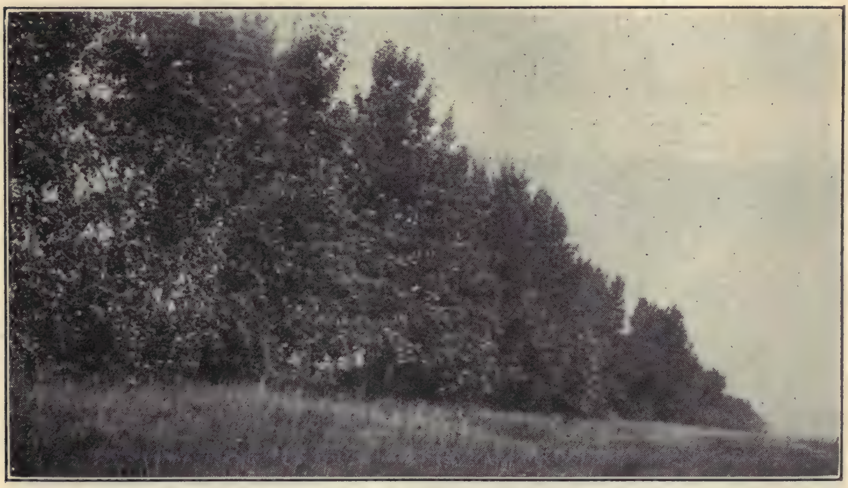

FIG. 10.—Northwest poplar. Wells County, N. Dak.

The lance-leaf cottonwood of the eastern Rocky Mountain slope is also a desirable tree for the western part of the northern and central

Plains. "Canadian poplar" is one of the Russian poplars which has been extensively planted in the northern Great Plains. It is hardy to winter cold and resists the ordinary amount of drought, but is subject to attacks by canker, a disease which soon girdles the tree, generally near the base or at a crotch, and kills that portion above the canker. This disease is quite common on all Russian poplars grown in this region. For that reason they are not recommended for general planting.

Buffalo berry (*Shepherdia argentea* Nutt.).—This low tree or shrub is native to the Great Plains, except Oklahoma and western Texas. It is very hardy and naturally grows in very difficult situations. It responds readily to cultivation and, except on low, wet situations, is recommended for windbreaks when cultivation can be given. It may grow to be 20 feet high under favorable conditions. Where little or no other native fruit is obtainable, the currantlike berries are eargerly sought for household purposes.

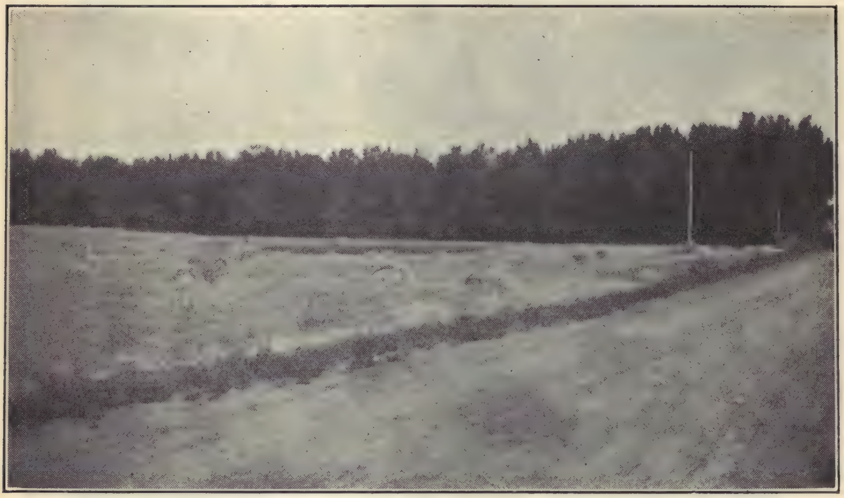

FIG. 11.—Cottonwood timber claim. Trees 35 years old. Steele County, N. Dak.

Osage orange (*Toxylon pomiferum* Raf.).—Osage orange is a very desirable tree for parts of the central and all of the southern Plains for shelter belts, hedgerows, and woodlots. It winterkills in northwestern Nebraska and in eastern Colorado, except in the Arkansas Valley. It is one of the best trees for upland planting in western Kansas and will live even when crowded by the grasses. It is very hardy and resistant to various forms of tree diseases. It does not make so rapid growth nor become a tree of so good form as the honey locust, but it is unsurpassed for posts, poles, and fuel. A 17-year-old hedge of osage orange near Hays, Kans., averaged 25 feet high and 6.4 inches in diameter. Twenty trees taken consecutively in a row produced 22 stakes and 47 posts. Another hedge 30 years old in western Kansas, from which many posts had been cut, it was found upon examination, would still yield from a 500-yard section 1,000 posts, some of them 12 inches in diameter. These posts are known to the lumber trade as "bois-d'arc," and are kept in stock by many lumber dealers in the southern Plains.

Chinese elm (*Ulmus pumila* L.).—The Chinese dry land elm, which was introduced by the Department of Agriculture in 1908, has grown well on heavy or light soils wherever tried, though apparently preferring the heavier soils. It is a fast-growing tree of dense foliage and inclined to low branching. It promises well for shelter-belt, woodlot, and lawn planting. A suspicion has arisen that there may be two forms or strains of this elm, one of which, coming from a different locality in China, is proving hardier than the other. In the northern Plains the trees of this species so far tried have not been entirely hardy, but under irrigation in South Dakota and in the central Plains without irrigation the species has proven very satisfactory.

Willows (*Salix* spp.).—The willows have not been found suitable for upland plantings in the northern Plains, though in the central Plains they have done fairly well, particularly on the banks of reservoirs. Their use is probably limited to the more moist situations. The common diamond willow has not proved very desirable when grown on upland, but it makes good growth along the bottoms. The laurel-leaf and Russian golden willows have been extensively tried out in the northern Plains and have often proved unable to endure either the cold of winter or the summer drought. They are not generally recommended for upland planting north of southern South Dakota, except on the eastern limits of the Plains. The same recommendations can be made as to planting the white willow.

Chokecherry (*Prunus virginiana* L.).—The chokecherry grows naturally in the valleys and river bottoms over practically the entire Great Plains region. It has been tried in a few places on the uplands in the northern Plains and has proved well worth planting for shelter-belt purposes. Except that it is not well adapted to very sandy or to low, wet situations, it is not particular as to soil, but it needs good care. It produces suckers profusely, and this is sometimes an objection to its planting.

Wild plum (*Prunus americana* Marsh.).—The wild plum is native over the Great Plains. Where planted as seedlings in shelter belts or woodlots it makes good growth and often produces fruit in five years. While it has not been generally planted, it is well worth trying out.

Catalpa (*Catalpa speciosa* Warder).—Catalpa will thrive under the proper conditions in western Kansas, Oklahoma, and Texas. It is not well adapted to the most rigorous sites, but it has been raised successfully on sandy loam soils where there is permanent water at a depth of 10 to 20 feet. It has been recommended by the Woodward Field Station in Oklahoma for low, wet bottoms where extensive drainage will be necessary before crops can be raised. (Fig. 12.) On such land, unless the soil is alkaline, catalpa will make a rapid growth and produce an abundance of posts. There are records of catalpa plantations in central and western Kansas that have produced 3,000 posts per acre and better in 14 to 18 years.

Black walnut (*Juglans nigra* L.).—Black walnut has been planted in different sections of the Plains as far north as Mandan, N. Dak.

Although it has proved hardy under severe conditions, it has thrived only under favorable conditions. There is a tendency for the trees to die out gradually in upland plantations. Black walnut winterkills in most parts of eastern Colorado, except in towns and cities and within 30 miles of the foothills. Only by planting on protected sites, preferably in valleys, by careful cultivation, and by the use of seed from hardy trees can black walnut be adapted to most parts of the Great Plains. Although this species offers possibilities for planting under favorable conditions in the central and southern Plains, it can not be recommended as a tree for general planting. It

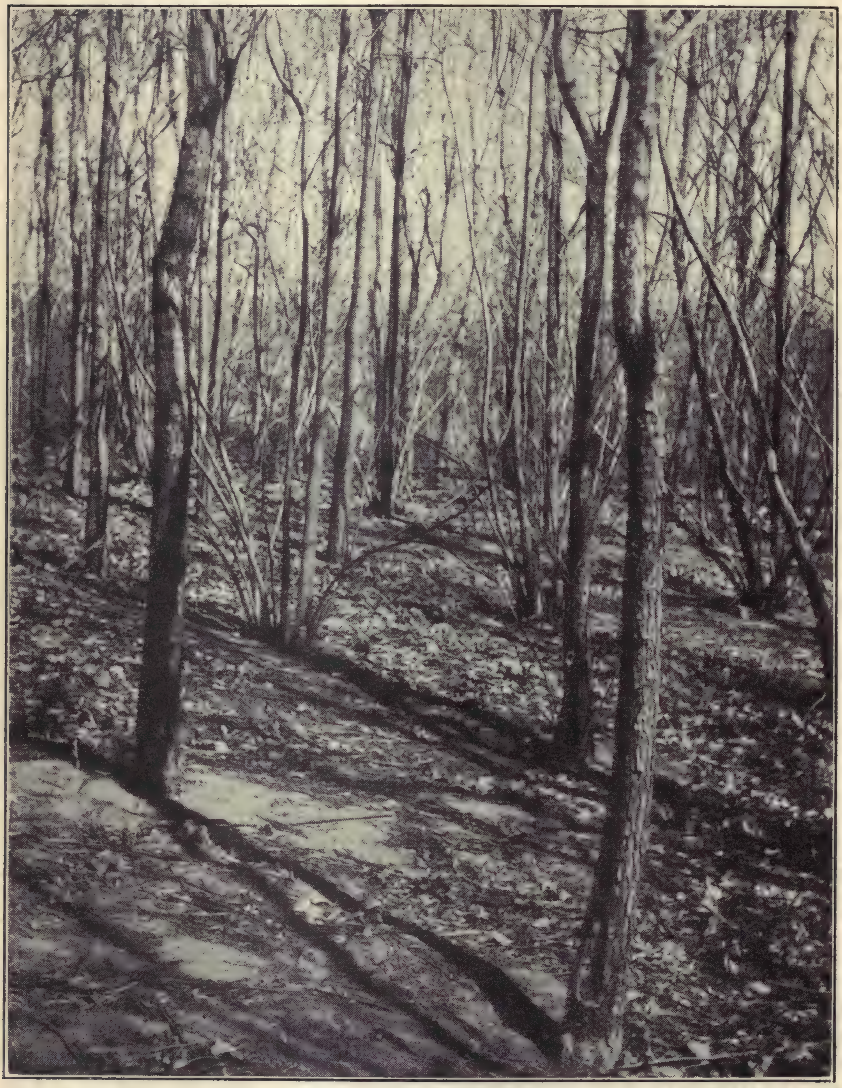

FIG. 12.—Hardy catalpa plantation on low ground. Woodward County, Okla.

should be planted in more or less open groves or woodlots. In southern South Dakota it has borne nuts after 8 or 9 years.

Soapberry (*Sapindus drummondii*).—Drummond's soapberry occurs naturally in river valleys and on hillsides, often on moist unfavorable sites, from southern Missouri through Oklahoma and into New Mexico. It appears to be free from injurious insects. It is not a rapid-growing tree, but often reaches a height of about 40 feet. This tree has been only occasionally planted in the southern Plains, but it is believed to be very hardy, and should make a good tree for that region. It has been successfully planted as an ornamental tree at Woodward, Okla., and at other towns in the southern Plains.

Silver or *soft maple* (*Acer saccharinum* L.).—Silver or soft maple has been extensively used in the central Plains principally for ornamental and windbreak planting. It matures at an early age, the wood is decidedly brittle, and large branches are often broken off in heavy windstorms. As silver maple is not very drought-resistant, it can be recommended only for valley planting where the roots will eventually go down to water. In such places it will quickly furnish shade and shelter.

CONIFERS.

Fewer conifers or evergreens than hardwood species are adapted to the Plains. None of these will withstand alkaline soils. They require more care, and the loss may be heavier; but those that are adapted to the region make more permanent and effective windbreaks than the hardwoods. It is best to prepare for conifers by setting out a belt of hardwoods of some of the species just discussed. After these hardwoods are several years old and are making good growth, the conifers should be set out in a belt on the leeward side and about 20 feet from them. The conifers will then not be subjected to the root competition of the hardwoods; they will receive protection from the prevailing winds; and they will be covered during the winter by the snow that drifts in to the leeward of the hardwoods.

Jack pine (*Pinus divaricata* DuMont de Cours).—A native of the Lake States, jack pine has proved very adaptable to the sandy and light loam soils of the northern and central Great Plains. It does not thrive on heavy clay soils or in low, wet situations. It does well planted either as a shelter belt or woodlot and is recommended for general planting. It is a very rapid-growing conifer, averaging under favorable conditions a foot a year for 40 years. Jack pine has been planted extensively, particularly by the Forest Service, in the Nebraska sandhills, where it adapts itself very readily to the conditions and makes rapid growth. Trees that have been planted 19 years now average 25 to 30 feet in height and are large enough for posts. A grove of jack pine planted 2 feet apart on a sandhill in Holt County, Nebr., in 1921, produced in 28 years approximately 36 cords of 4-foot wood per acre. Although the trees were planted so densely that they retarded each other's development, trees large enough to produce 742 fence posts and 58 small telephone poles per acre had developed. (Fig. 13.)

Western yellow pine (*Pinus ponderosa* Laws).—The western yellow or bull pine is native to the southeastern part of Montana and western North Dakota and south through the Black Hills to northern Nebraska and eastern Wyoming, Colorado, and New Mexico. Although it has been comparatively difficult by planting to obtain suitable stands of this tree in sections of Montana, North Dakota, and South Dakota, it has done very well in Nebraska and Colorado. It grows more slowly than either the jack or Scotch pines, but, once established, is very hardy. This tree has been extensively planted in the Nebraska sand hills by the Forest Service, where, after becoming thoroughly established, it has made an excellent growth, although handicapped to some extent by an insect, the pine-tip moth.

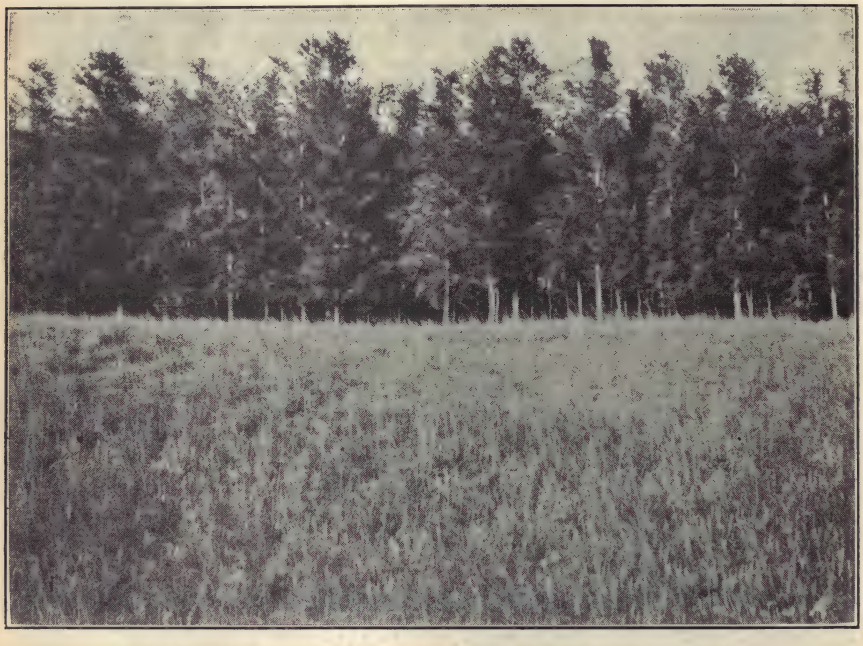

FIG. 13.—Jack pine plantation 30 years old. Holt County, Nebr.

A western yellow-pine plantation established in 1888 in Rock County, Nebr., with 3-year-old forest-pulled seedlings spaced 11 feet apart, showed after 31 years a total volume of 2,339 cubic feet, or approximately 30 cords of 4-foot wood per acre. The average diameter 4½ feet above the ground was 10.1 inches, and the average maximum height was 45 feet. There were 113 trees per acre averaging 11.6 inches in diameter and capable of producing two railroad ties each. (Fig. 14.)

Scotch pine (*Pinus sylvestris* L.).—The Scotch pine is a very hardy tree and should make good growth in both shelter-belt and woodlot plantings. It does not make as rapid growth at the start as jack pine, but passes it within 10 years. It may be planted with a fair likelihood of success in most parts of the Great Plains region, except, perhaps, on low, wet situations. It is preferable to plant only the Riga or northern Europe variety, because of its more rapid growth and better form. (Fig. 15.)

Chinese arborvitæ (*Thuya orientalis* L.).—The Chinese arborvitæ is recommended for general shelter and lawn planting for Kansas and southward, and for irrigated sections in Nebraska. Unlike the American arborvitæ, it thrives on heavy upland or limestone soils. It is not a large tree, but its small size is more than compensated for by its hardiness and luxuriant growth. As it is an introduced tree from China, little is known concerning its behavior in old age. This tree is not considered suitable for woodlot plantings.

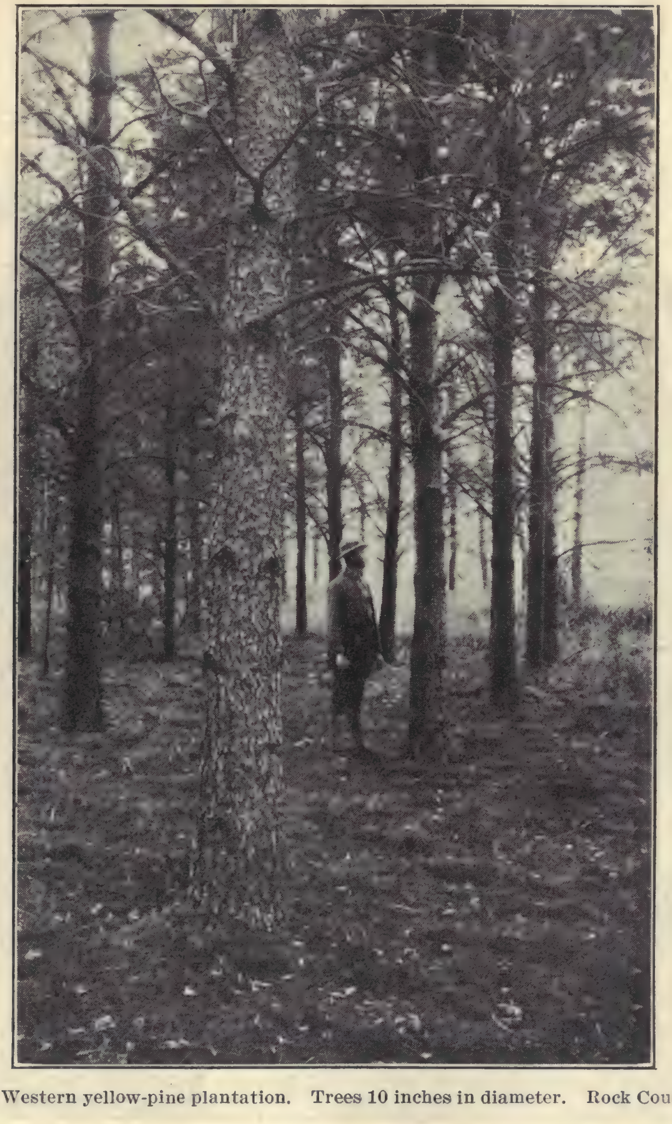

Fig. 14.—Western yellow-pine plantation. Trees 10 inches in diameter. Rock County, Nebr.

Cedars (*Juniperus virginiana* L. and *Juniperus scopulorum* Sarg.).—The red cedars, both eastern and western varieties, are well worth planting over the entire Great Plains. They are hardy under severe conditions and are comparatively easy to transplant from their native sites. They form a very effective shelter belt both winter and summer. Some objections are raised to the cedars because of the presence of the "cedar-apple" fungus, a disease which also affects apple trees in the immediate vicinity. As orchards in the

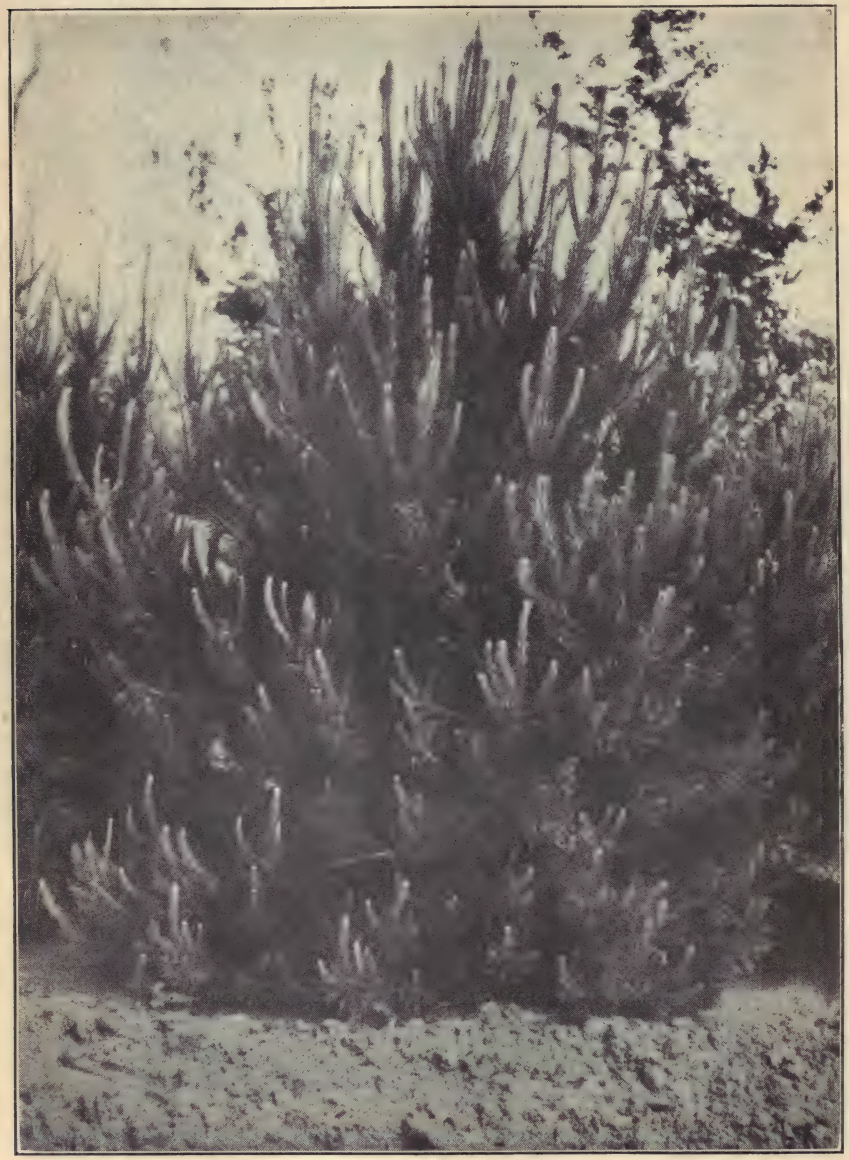

FIG. 15.—Scotch pine 6 years old. Woodward, Woodward County, Okla.

high plains are very scarce and not likely to be common for some years, this objection is not a serious one. According to Prof. B. O. Longyear, of the Colorado Agricultural College, the disease coming from cedar apples on *J. scopulorum* does less harm to fruit trees than when it is transmitted from *J. virginiana.* Scopulorum is the handsomer tree in Colorado and is called " silver cedar " by nurserymen.

Black Hills spruce (*Picea canadensis* B. S. P.).—The Black Hills variety of the white spruce is recommended for general shelter-belt planting in the northern Great Plains and in Nebraska. It makes a fairly rapid growth and is extremely hardy.

Colorado blue spruce (*Picea parryana* Sarg.).—The Colorado blue spruce is native to parts of Wyoming, Colorado, Utah, and New Mexico. When planted on dry-land sites in the northern and central Great Plains, it has generally proved satisfactory. It grows best on the clay soils. It makes slower growth than the Black Hills spruce, but is hardy.

In addition to the above conifers, limber pine (*Pinus flexilis* James) has been successfully planted in several places in eastern Colorado and pinyon pine (*Pinus edulis* Engelm.) in the panhandle of Oklahoma and Texas and in eastern New Mexico.

MIXED PLANTATIONS.

Most of the older plantations in the Great Plains have been made with but a single species. For shelter and woodlot planting, it is sometimes preferable to plant two or more kinds of trees in mixture. Species that have scant foliage may well be combined with those having denser crowns, so as to provide a heavier shade which will kill out the grass and weeds. It may be advisable to plant a long-lived species with one which comes to early maturity. A mixture gives some assurance of a stand of trees even if one of the species is killed or seriously injured by insects or disease.

Tentative conclusions from experimental plots of mixed species indicate that the following combinations should prove successful on soils and in regions adapted to both species:

Boxelder and green ash.
Green ash and American elm.
Northwest poplar and boxelder.
Green ash and honey locust.
Cottonwood or northwest poplar and green ash.
Cottonwood or northwest poplar and silver maple.
Honey locust and hackberry.
American elm and hackberry.

These combinations will do better if the outer rows are planted to Caragana or Russian olive. The dense screen that these species form assists in keeping out the wind, the light, and an encroaching growth of grass.

ORNAMENTAL PLANTING.

Many of the more desirable hardwoods of the Mississippi Valley have been acclimated for planting as lawn, park, and street trees in the towns of the Great Plains region. In towns the trees have more protection from the drying winds, and it is possible to furnish them the needed water. Some towns now prohibit the planting of boxelder, black locust, and female cottonwoods, and recommend such trees as American elm, honey lucust, hackberry, bur oak, black walnut, and American linden. Red oak and pin oak grow successfully in the city of Denver. Conditions vary so much throughout the range of the Great Plains that it is advisable to ask the advice of the nearest State or Government agricultural experiment station before planting any species which has not already been tried in the vicinity and proved hardy.

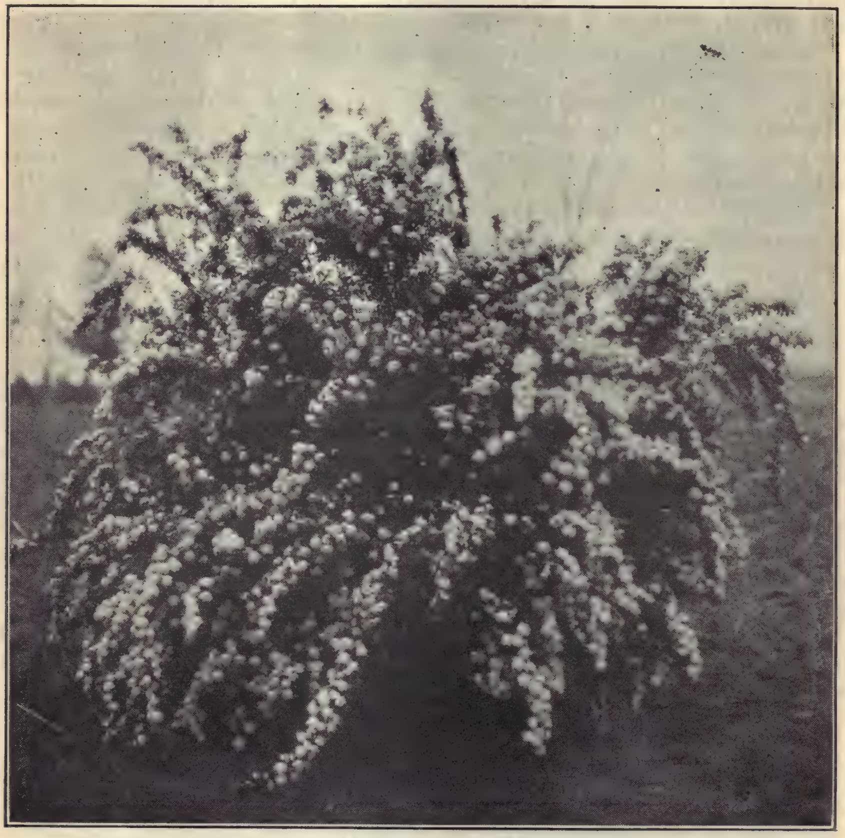

FIG. 16.—*Spiræa vanhouttei.* Woodward, Okla.

Many shrubs have been found hardy for the Great Plains. (Fig. 16.) By planting them in groups around the farmhouse, in corners of the yard, and as screens to conceal outbuildings, the farm home will not only be a more desirable place in which to live, but the value of the farm will be greatly increased.[2]

The following shrubs have been found hardy and drought-resistant for the northern and central Great Plains:

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[2] See U. S. Department of Agriculture Farmers' Bulletin No. 1087, "Beautifying the Farmstead."

Missouri flowering currant (*Ribes aureum*).
Dogwood (*Cornus stolonifera* and *C. sibirica*).
Common lilac (*Syringa vulgaris*).
Himalayan lilac (*Syringa villosa*).
Persian lilac (*Syringa persica*).
Spirea (*Spiræa arguta, S. vanhouttei,* and *S. sorbifolia*).
High-bush cranberry (*Viburnum opulus americana*).
Snowball (*Viburnum opulus sterilis*).
Tartarian honeysuckle (*Lonicera tatarica* and *L. morrowii*).

The flowering currant and dogwood occur naturally in many parts of this region and are especially desirable for ornamental plantings. Buffalo berry, Russian olive, and Caragana, previously listed as shelter-belt trees, have also been found valuable for hedges and ornamental planting.

The following list of hardy shrubs is recommended for the southern Plains:

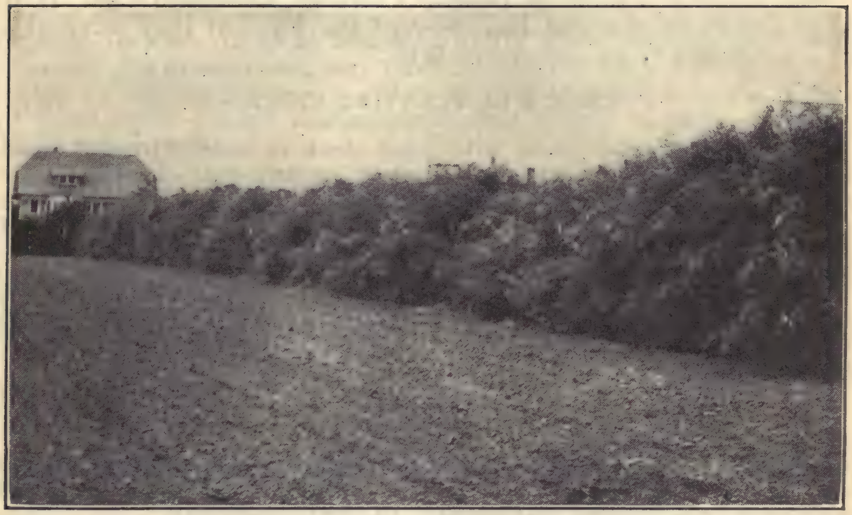

FIG. 17.—Tamarisk hedge 3 years old. Woodward, Woodward County, Okla.

Rough-leaved cornel (*Cornus asperifolia*).
Japanese quince (*Cydonia japonica*).
Chickasaw plum (*Prunus angustifolia*).
Smooth sumac (*Rhus glabra*).
Missouri flowering currant (*Ribes aureum*).
Plum-leaved spirea (*Spiræa prunifolia*).
Coralberry or Indian currant (*Symphoricarpos vulgaris*).
Persian and common lilac (*Syringa persica* and *S. vulgaris*).
Early-flowering tamarix (*Tamarix parviflora*).
Van Houtte's spirea (*Spiræa vanhouttei*).

The tamarix, in addition to having ornamental value as a shrub, is being satisfactorily used as a hedge and windbreak. (Fig. 17.) Many other shrubs have been found hardy for planting on the Great Plains, but the foregoing lists can be depended upon.[3]

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[3] Acknowledgment is due to T. K. Killand, assistant horticulturist of the Northern Great Plains Field Station, Mandan, N. Dak., for the list of shrubs adapted to the northern portion of the Great Plains, and to Christian Jensen, superintendent of grounds and landscape designer of the Oklahoma Agricultural and Mechanical College, Stillwater, Okla., for the list of shrubs for the southern half of the Plains.

LOCATION OF THE PLANTATION.

The shelter belt should be planted on the side of the farm buildings from which the prevailing winds come, which for most of the region means either the northwest or the southwest. It should be long enough to protect the buildings, orchard, and possibly the feed yards, and to be thoroughly effective should be not less than 40 feet wide. It should not be closer than 100 feet to the principal buildings, and it might be well to leave a greater distance, so that there will be ample room for new buildings or for planting more trees. If the trees are planted too close to the buildings, snow is apt to sift through the windbreak and form drifts near buildings. If the windbreak is made up of a belt of hardwoods and then another belt of conifers about 20 feet distant on the sheltered side, the space between them will serve as a snow trap.

The woodlot should be located wherever convenient; but, if it is placed along the west boundary of the farm, it may serve also as a windbreak to an orchard or field.

CHOICE OF PLANTING STOCK.

A plantation established with poor stock is handicapped. Good stock should be chosen. One-year-old or two-year-old hardwood seedlings give best results under normal conditions. Older stock should be avoided. It is more expensive and requires more time and attention to plant. If, however, conifers are planted, nothing smaller than 3-year-old transplants should be used. Transplants are preferred because their more fibrous root systems make them better able to absorb available moisture and accommodate themselves to their new site.

SOURCE OF PLANTING STOCK.

Hardwood seedlings may be purchased or readily grown from seed in the home garden. By collecting seed from trees which occur naturally in the region the planter will be certain of securing seedlings which are true to name and adapted to local conditions.

American elm and silver or soft maple seeds should be sown as soon as they are ripe, which is in May or June. Caragana seeds should be picked in July before they are entirely ripe on account of a habit which the pods have of splitting open when dry and throwing the seeds out. These seeds sprout readily. They may be sown as soon as picked or in the following fall, or they may be stratified and sown the next spring. If the seeds are sown as soon as gathered, the plants will make considerable growth the same summer and will be ready for transplanting to their permanent site at the end of the following summer. Seeds of green ash, boxelder, honey locust, and Russian olive should be collected in the fall, stratified in moist sand over winter, and sown the following spring.

The seeds should be sown in rows, in much the same manner as vegetable seeds. The plants should be watered and cultivated so they will become as large as possible in one growing season. After the middle of August, only enough water should be applied to keep the ground from drying out completely in order to harden the tender wood and thus prevent damage to the plants from early frosts.

Cottonwoods and willows are generally propagated by means of cuttings. These cuttings, which are best made in the fall or early winter, should be from 7 to 10 inches in length and taken from 1-year-old or 2-year-old twigs of healthy trees. Cuttings should always be made with a sharp knife to avoid bruising the bark. If trees free from seed or "bloom" are desired, cuttings should be taken from trees which observation has shown do not produce seed. Cuttings should be buried in cool, moist, well-drained sand until spring. Best results will then be secured by setting them in the garden for a year. Here, where they can be given care, they will take root, and the following spring they may be set out on the permanent site as 1-year rooted cuttings. Unrooted cuttings, however, will often grow if set out directly on well-tilled irrigated land or in subirrigated river bottoms.

Conifers are much more difficult to raise from seed than are hardwoods, and, unless a large project is undertaken, it is inadvisable to attempt to grow them at home. Thrifty stock may be purchased from reliable nurserymen, and sometimes at cost from nurseries maintained by the States. Stock grown as near as possible to the region of planting is always preferable to that grown in more southern districts.

PREPARATION OF SOIL.

Before the planting, the soil must be thoroughly worked up and the sod completely rotted. On new ground it is usually desirable to do the breaking at least two years before planting the trees. During the season following the breaking, the land should be disked, harrowed, or cultivated as often as is necessary to keep the ground clear of weeds, grass, or other vegetation. Clean summer fallow of this type is the best method of preparing land for the planting of trees.

On certain portions of the Plains region where the soil is a sandy loam, the sod not so heavy, and there is danger of the soil's being blown, plowing 12 months previous to planting is sufficient. To prevent winter blowing, such areas should be ridged in the fall by being gone over with an ordinary cultivator or lister.

Better results are usually secured on ground which has been under cultivation for several years. The land should not be cropped to grain, alfalfa, or sweet clover the summer previous to planting, as these crops will use the moisture that should be stored up for the trees.

TIME OF PLANTING.

Throughout the entire Plains region the best results are secured from early spring planting. This gives trees the advantage of an entire growing season in which to become established before they are subjected to the rigors of winter. They also have the advantage of the accumulated winter moisture, and the liability of loss from winter heaving caused by alternate freezing and thawing is slight. Fall planting may sometimes be successful if it is possible to give each tree individual attention, but for general planting it usually results in failure and is not recommended. It is a decided advantage if the planting can be done on damp, cloudy days. Hot, windy days should be avoided for tree-planting operations.

METHODS OF PLANTING.

Planting methods are largely determined by the size of the stock and the condition of the site. Regardless of the method followed, however, certain rules should be observed. When trees are purchased, the package upon arrival should be opened in a barn or shed and the roots well moistened. They should not be exposed to the sun or drying wind. If the roots of each tree are bound with earth and burlap, the burlap need not be removed and the whole bundle should be planted. If the weather permits, the trees should be planted immediately. This insures best results. If that is not possible, they should be "heeled in" in a sheltered location. A trench is dug 8 to 12 inches deep, with one sloping side, against which the trees are placed in thin layers with the roots extending downward. The roots are then well covered with moist soil. Trees may be kept in this way for some time, although warm weather may start their growth. Trees grown at home should not, of course, be dug up until they are to be planted.

In planting, great precautions are necessary to keep the roots of the trees from drying out. They should be kept moist at all times. This is especially important in the case of conifers, for they are easily killed by the exposure and consequent drying out of the roots. On dry, windy days a few minutes' exposure is fatal. The trees may be wrapped in a wet piece of burlap or carried in a bucket, with the roots covered with moist dirt. A method successfully used in a number of places and especially desirable for conifers is that of filling a tank half full of very soft mud and placing the roots of the trees in this. The tank is hauled around on a sled as the trees are planted. The film of mud on the roots keeps them from drying out so rapidly if they should be exposed.

If the soil is not very moist at the time the trees are planted, it is advisable to water them after they are set out wherever that is practicable. This would, of course, be a laborious task on most dry-land farms where water would have to be hauled.

FURROW PLANTING.

A furrow from 8 to 12 inches deep, depending on the length of the roots, should be plowed along a staked line. While the tree is held in an upright position with roots in the bottom of the furrow, the soil should be pulled in from both sides and tamped solidly around the roots, so that the tree will stand upright. The furrow is then filled with soil and leveled. The trees should be set about an inch deeper than they were in the nursery, and the soil should not be hilled up. Not more than one or two furrows should be opened at a time. If a furrow is left open too long the soil will become dry and the result will be disastrous to the trees.

INDIVIDUAL HOLES.

This method is best adapted for planting trees with large root systems or for use on heavy or rocky soil, although it must again be emphasized that the only certain way of getting results in the Plains region is to plant in thoroughly tilled soil. Steep hillsides which can not be plowed can be planted by this method. A hole should be dug wide enough and deep enough to accommodate the tree roots without crowding. After the tree has been set in the hole with its roots extended, the soil should be pulled in over the roots and tamped thoroughly. Large rocks and sod should not be allowed to fall in around the roots because of the possibility of their causing air spaces, which would allow the roots to dry out. It is best to plant the tree immediately after digging the hole.

SLIT METHOD.

In the slit method a wedge-shaped hole is opened in the ground by inserting a spade and moving it backward and forward. Into this opening the tree roots are inserted full length, and the earth is pressed firmly around them by a thrust of the foot or by making another slit with the spade several inches beyond the tree and pressing the soil toward it. This method is adapted to light, sandy soils where, because of the danger of the soil's drifting, it is unwise to break up all of the sod, and to hillsides where complete plowing might result in erosion. In such sites, furrows may be plowed 6 or 8 feet apart and the trees planted in them. On hillsides the furrows should follow the contours.

NUT PLANTING.

Such trees as oaks and black walnut, which are grown from large nuts, are best propagated by planting the nuts where the trees are to grow, as the long taproots of such trees make successful transplanting from the nursery to the field quite difficult. A good method is to bury walnuts in a shallow pit over winter. When the nuts begin to sprout in the spring they should be planted in shallow holes in well-tilled land and covered lightly.

PLANTING CUTTINGS.

Early in the spring cuttings should be set out in well-tilled soil in a slanting position, with the buds pointing upward, and with about an inch of the cutting protruding above the ground. The cuttings may be set in a furrow or in holes made with a bar or dibble. After they are set, the soil should be pressed firmly about them.

SPACING.

For shelter belts it is desirable to have the trees far enough apart so that they can be cultivated from three to five years, but not so far apart that their value for wind protection will be minimized. Such close spacing as 4 by 4 feet, which has been tried out in certain localities, has not been found practicable in the Plains region in the United States. Trees planted as close as this are difficult to cultivate and are likely to be stunted. It is very doubtful whether the shade provided by closely spaced trees would conserve enough soil moisture to support them during those periods of drought extending over several years to which the region is liable.

As a result of extensive tests in the Plains region, a spacing of 8 by 6 feet or 8 by 8 feet is recommended for shelter-belt planting.

This will permit cultivation both ways for a period of two to five years. It will also provide for sufficient trees so that, if some should die, enough will ordinarily live to make any replanting unnecessary. Some loss is almost certain to occur in every plantation.

Species such as Caragana, buffalo berry, and Russian olive, which are often planted as 1-row or 2-row hedges or windbreaks, should be spaced 2 or 3 feet part in the row.

For woodlots a spacing of 8 by 6 feet is advocated, in order that trees with straight stems and few branches may be produced. If this proves to be too dense in those portions of the Plains having the least rainfall, the smaller trees may be cut out and used for posts or fuel.

On river bottoms or on subirrigated land trees may be spaced closer than on dry land. There a spacing of 6 by 6 feet is recommended for woodlots and 8 by 4 feet for shelter belts.

Some tree planters have advocated planting trees as far apart as 15 by 6 feet or even 24 by 6 feet, because available soil moisture is the controlling factor in tree growth, and ordinarily there is not sufficient moisture on the dry-land farms of the Great Plains to support a denser mature stand. Such wide spacing necessitates clean cultivation for many years, and, as farmers sometimes neglect this on account of the press of other work, their woodlots are soon overgrown with weeds and a heavy loss of trees follows. Many old timber claims, throughout the Plains, with their few struggling, misshapen trees contending against the vegetation, are examples of this. Experience has shown that it is better practice to space the trees more closely, so that cultivation may be discontinued after the fourth or fifth year, when the trees will have shaded out the grass.

CARE OF PLANTATIONS.

CULTIVATION.

A large proportion of failures in plantations is caused by the negligence of the planters. It is a mistake to suppose that trees will live and thrive if they are set out in a weedy or grassy area and then left to shift for themselves. The slow, scrubby growth of natural groves of trees in the Great Plains and the miserable appearance of neglected planted areas are excellent illustrations of the truth of this. Cultivation is just as necessary in establishing a successful plantation of trees as in other lines of agriculture, and the results are proportionate to the amount of labor expended in keeping the soil loose and free from weeds. Cultivation stimulates tree growth, and no other operation helps so much to lessen the losses caused by insufficient moisture.

The area should first be cultivated at least one year and preferably two years before the trees are planted. After planting, cultivation should be repeated as often as necessary to keep the weeds down and should be continued every season until the trees have grown too large for the work to be done between the rows. Cultivation should extend 5 or 10 feet beyond the limits of the plantation. This strip of cultivated soil will retard the encroachment of grass and weeds and also serve as a firebreak. Under no circumstances should the weeds be allowed to grow so high that a plow must be used to destroy them; weeds rob the trees of moisture, and a plow or any deep cultivator may injure the fine tree roots. A one-horse cultivator can be used to best advantage if the trees are spaced as recommended.

The only other method that seems practicable in eliminating weeds from small plantings is to fence the area after the third or fourth season and use it for a chicken yard. The chickens will keep down the weeds and insects and scratch up the soil.

THINNING.

The object of thinning is to remove those trees which, because either of their unhealthy condition or crowded position, are retarding the growth of the more desirable individuals. Just as an overcrowded stand of vegetables is thinned by a gardener, so the poor trees in a woodlot should be cut out. The result is the best development of those remaining. The best-formed, most valuable, and most healthy trees should be selected to remain. Need of thinning is indicated if, on account of crowding, there are many dead or dying trees in the stand, or if the trees are very slender in proportion to their height.

Although thinnings will not ordinarily be necessary until the wood lot is 15 to 20 years old, on irrigated land they may be desirable earlier. Care should be exercised not to remove so much material that the sun will shine through and induce a growth of grass under the remaining trees. The openings in the tops should close in three or four years. The fact should not be overlooked that in a large grove the shade afforded by the crowns of the trees takes the place of cultivation in keeping the grass down and lessening the evaporation of water from the soil. The first thinning will yield fuel and small posts, and, if the poorer material is removed each time, each subsequent thinning will remove bigger and better material.

A shelter belt should ordinarily be thinned only if many of the trees are plainly in an unhealthy condition. Unless considerable care is exercised, the removal of trees from a shelter belt will lessen its protective value.

PRUNING.

Pruning of the branches of trees in a plantation is in general unnecessary and, because of the cost of labor involved, undesirble. Pruning in shelter belts is not at all advisable, as a dense growth not only gives the most protection to the farm buildings but also protects the trees themselves. The bushy growth protects the trunks of the trees from sun scald, prevents the growth of grass and weeds, and retards evaporation. Species like the Siberian pea tree, which do not develop a main stem but send out a dozen or more shoots, should not be pruned. In the Plains region the greatest value of conifers is in the protection which they afford against wind. As low branches make them more effective in this respect, they should ordinarily not be pruned.

If a young tree is frozen to the ground for a few years in succession it will send out a number of shoots from the base and make little growth in height. To stimulate growth, all of these shoots except one should be cut off close to the base. This shoot should be allowed to become the leader, and, if shelter is the purpose of the planting, none of the branches it sends out should be pruned.

In woodlot plantations where it is desired to produce a good grade of material, it may sometimes be profitable to prune the best trees by cutting off such dead and brittle limbs as can be reached. Dead branches which persist on some hardwoods are likely to form loose knots and should be removed. If, because of wide spacing, the trees are assuming a poor timber form, it may be necessary to correct this condition by pruning.

Pruning may be done at any season, but fall or winter, when the tree is dormant, is the preferable time. It should not be overdone. If a tree is pruned too far up, it may become top-heavy and be easily broken off by a severe wind. Sharp tools should be used. Branches should be cut off close to the main trunk so that no stubs are left through which wood-rotting fungi may enter the tree.

PROTECTION.

AGAINST CATTLE AND RODENTS.

Grazing animals should never be allowed to use the plantation as a pasture. The animals almost invariably cause damage to the trees by nipping off the branches, peeling the bark, trampling the small trees, and packing the ground hard and dry, thus robbing the trees of much-needed moisture. Every plantation should be fenced with rabbit-proof woven-wire fence to keep out live stock and rabbits.

The jack rabbit is the worst animal pest with which the grower of trees in this region has to contend. It not only strips the bark from the older trees, but will also cut off seedlings at the ground or at snow line. It especially prefers elm and ash, but will cut off poplar, willow, and young jack pine branches when they extend above the snow. Rabbits like alfalfa better than trees, and, if a stack of alfalfa is near by, they will seldom bother the trees.

Rabbits may be poisoned by sprinkling a strychnine solution on alfalfa leaves. This is prepared by dissolving one ounce of strychnine sulphate in 2 gallons of hot water and sprinkling it over 10 pounds of alfalfa hay leaves. The leaves should be mixed thoroughly until all moisture is absorbed. Other methods of poisoning may be learned from the Bureau of Biological Survey, Washington, D. C., from State foresters, or from experiment stations listed on page 34 of this bulletin.

Rabbits may be trapped readily by the following method, which has been suggested by the Kansas State Agricultural College Experiment Station in its Circular No. 17:

> Sink a barrel or keg in the ground level with the surface. Fit the head slightly smaller than the top and allow it to swing freely on a rod or old broomstick. Pieces of apple or corn may be fastened on the outer edge of the cover, and when the rabbit attempts to get these, the lid slips in and he slides into the barrel, while the lid, which is slightly heavier on one side than the other, assumes its original position. The heavier side should rest against a heavy nail or bolt so that only the lighter side of the lid will drop. The whole thing should be covered over with brush.

In many parts of the Great Plains, pocket gophers cut off the roots of young trees. These rodents may be poisoned by sprinkling a mixture of strychnine and saccharine upon cubes of sweet potatoes or carrots, which are then inserted into the underground runways. Trapping is the surest method of exterminating pocket gophers, and several good traps for this purpose are on the market.

AGAINST INSECTS.

Various species of trees are attacked by insects in different parts of the Plains region. Poplar beetles and their black larvæ eat willow and poplar leaves. These beetles suggest the Colorado potato beetle in shape, but they are somewhat smaller and are black in color tinged with blue and more or less striped or spotted with yellow or orange. They appear when the leaves begin to come out in the spring and are at their worst during the month of June. Four to five broods may be produced before fall. Their attack is followed by disastrous results to the foliage and later by the death of the trees. Spraying with lead arsenate, prepared as directed on the containers, will destroy the insects. The spraying will yield most satisfactory results when the leaves are about half grown. The reappearance of the beetles in great numbers may necessitate a repetition of the treatment during the season.

The large, green, wormlike larvæ of certain moths are very destructive to the foliage of poplars and boxelders. One large worm may eat all the leaves on a young tree in a short time. A thorough spraying with lead arsenate should control this pest. Hand picking is also often resorted to.

Blister beetles are found on the young shoots of the Caragana in the month of June. They are of three kinds, the gray and the black (about three-fourths of an inch to 1 inch long), and the metallic blue (1 to 2 inches long). Spraying with lead arsenates does not seem to kill them, but drives them to other plants. They do, however, eat leaves sprayed with Paris green and are killed. The Paris green, however, does not adhere so well to the leaves and is generally more expensive. The Caragana does not seem to suffer much from these beetles unless entirely denuded. This denuding frequently weakens the trees to such an extent that they die within a year or so or leads to further and more severe attack each following year until death results. When only the ends of the young growth are eaten, the trees will often put out new leaves later in the summer. Blister beetles also attack green ash, Russian olive, and hackberry, sometimes doing considerable injury to young plantations.

The pine-tip moth (*Evetria bushnelli*) causes some damage to pine trees planted in western Nebraska by boring into the young shoots and hollowing them out for a distance of several inches. This distorts the growth of the tree if the leader is attacked several years in succession. There is no practical remedy for the control of this pest.

Black locust is well adapted to the southern part of the Plains, but its planting can hardly be generally recommended because of the damage done by the locust borer. Success has been attained in planting black locust in the low, wet bottom lands of rivers in western Texas and Oklahoma. The absence of the borers here has been ascribed to planting the trees so densely that the trunks are shaded. The shade, together with the rapid growth on the bottoms, seems to make the locust almost safe from attack. Green ash has also been severely injured in portions of the Plains by a borer, but in most places this insect appears to be held in check by nature. The cottonwood borer causes some damage, but for the most part it is controlled by natural enemies.

Insects may cause serious damage. If an insect attack is severe, aid should be sought from the Bureau of Entomology, Department of Agriculture, Washington, D. C., or from the State experiment stations.

AGAINST FIRES.

In places where there are few cultivated farms and there is danger from prairie fires, a fire line 5 to 10 feet wide should be plowed around the plantation. If it is placed next to the outer rows of trees and kept clean, the growth of the exterior trees will be greatly stimulated. In sections where there is danger of the soil's being blown, the fire line should not be placed adjacent to the trees; for, if the soil is blown, small trees may be buried or the roots of larger ones may be uncovered.

WINTER INJURY.

Trees are more or less subject to winter injury throughout the Plains region. The causes of this are briefly as follows:

Trees that are not hardy to the section wherein they are planted are subject to freezing in the fall and winter. This is generally due to the inability of the plant to stand the severe winter, or to failure to ripen the year's growth of wood in the fall because of the shorter growing season of the region.

Other trees are subject to sun scald on the trunks and branches during winter and early spring. This causes the tissue on the south side to die and leaves a scar that forms a ready entrance for diseases.

Even hardy trees often dry out in the winter or spring during prolonged periods of drought. These usually recover and resume their natural growth unless killed to the ground.

Trees are often tender the first few years after planting, but later become acclimated and are thereafter hardy.

RESULTS.

There are very few plantations more than 15 years old in the Great Plains, in the development of which the principles of good tree planting, such as the proper selection of species and careful methods of planting and cultivation, have been followed. Hence there are few available figures showing the growth and the products that may be obtained. A large number of tree claims were established between 1878 and 1891 under the timber-culture act; but some of these plantations have been damaged by prairie fires, some have been ravaged by insects, some have been cut out or have died out, and on the whole they have been sadly neglected. (Fig. 18.)

Such data as are available indicate that despite scant rainfall, drying winds, and extremes of heat and cold, valuable wood products can be obtained from planting in the Plains region. Some of the hardiest species are either of poor quality or of poor form for posts or other timber products. Their value lies in their ability to grow at all or in their low-branching, compact habit, which is so necessary for making shelter and which is of more importance in the Great

Plains region than the production of clear timbers. It is well to remember, however, that even nondurable fence-post woods, which the farmer situated long distances from the railroad may be forced to use, may be given an average life of 20 years by treating them with creosote.[4]

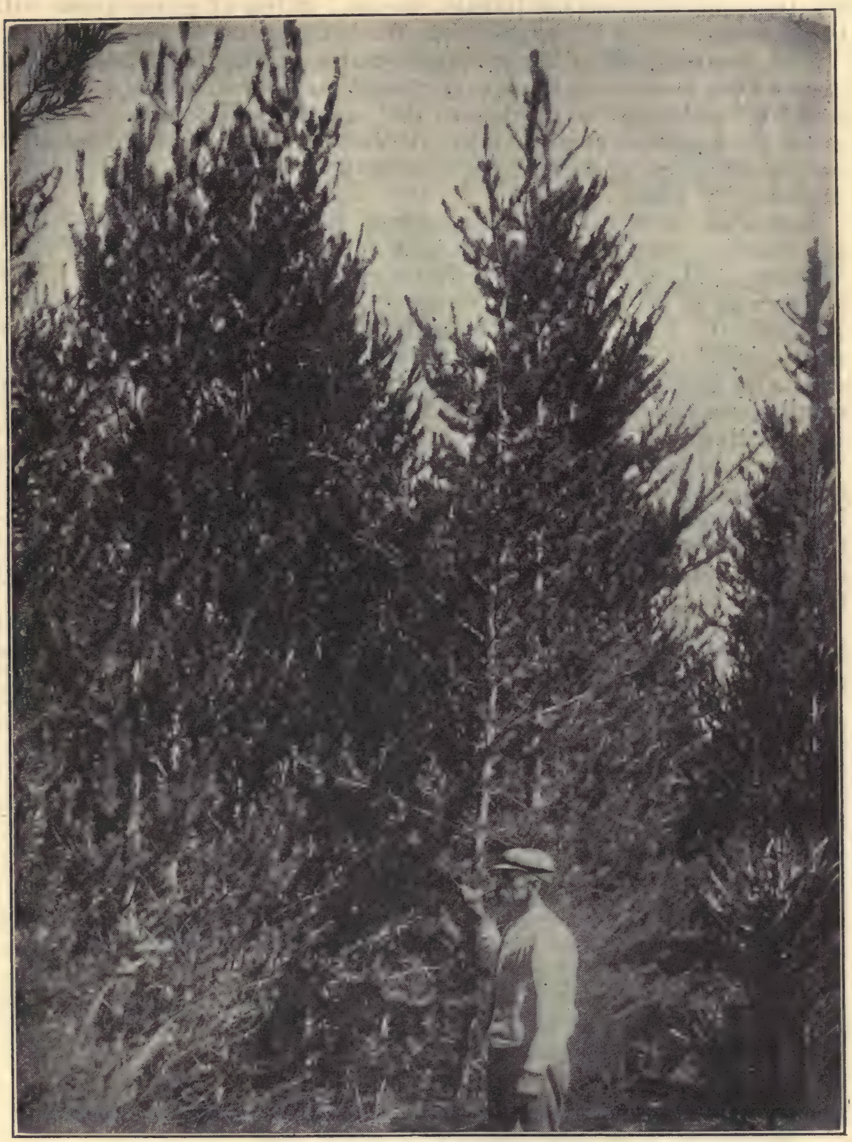

FIG. 18.—Jack pine plantation 14 years old. Height 12 to 24 feet. Holt County, Nebr.

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[4] See U. S. Department of Agriculture Farmers' Bulletin No. 744, "The Preservative Treatment of Farm Timbers."

SOURCES OF INFORMATION AND PLANTING STOCK.

Private nurserymen are usually able to supply planting stock of the trees more important in each region. A list of nurserymen will be supplied by the Forest Service, Washington, D. C., upon request.

The Northern Great Plains Field Station at Mandan, N. Dak., furnishes some forest-tree stock to dry-land farmers only in the western half of North and South Dakota and in eastern Montana and Wyoming for cooperative experimental plantings. Further information may be obtained by writing the Northern Great Plains Field Station, Mandan, N. Dak.

Residents of the sixth congressional district in western Nebraska may receive trees free, so far as they can be spared, from the Bessey Nursery at Halsey, Nebr. Applications should be made to the forest supervisor at Halsey before March 1 of the year in which the trees are desired. Each applicant usually is given not to exceed 200 trees of species that have been found adapted to this region, as the intent of the legislation authorizing this distribution is to interest people in tree planting rather than to furnish large numbers of trees for woodlot planting.

The State forester of Colorado sells trees at the cost of production to residents of that State. Particular attention is being paid to raising trees adapted to the treeless eastern half of the State. Information regarding the distribution and price lists may be secured upon application to the State forester, Colorado Agricultural College, Fort Collins, Colo.

Trees are sold to residents of Kansas by the Fort Hays Experiment Station, Hays, Kans. A catalogue and price list of trees will be mailed upon application to the station.

In the Great Plains region, persons who wish more specific information should apply to one or more of the following sources:

NORTH DAKOTA.—Northern Great Plains Field Station, Mandan, N. Dak.
  North Dakota Agricultural College, Agricultural College, N. Dak.
SOUTH DAKOTA.—Northern Great Plains Field Station, Mandan, N. Dak.
  State College of Agriculture, Brookings, S. Dak.
MONTANA.—Northern Great Plains Field Station, Mandan, N. Dak.
  State College of Agriculture, Bozeman, Mont.
  State forester, Missoula, Mont.
  District forester, Forest Service, Missoula, Mont.
WYOMING.—Northern Great Plains Field Station, Mandan, N. Dak.
  College of Agriculture, Univ. of Wyoming, Laramie, Wyo.
NEBRASKA.—Forest supervisor, Halsey, Nebr.
  State forester, Department of Conservation and Soil Surveys, Lincoln, Nebr.
COLORADO.—State forester, Fort Collins, Colo.
  District forester, Forest Service, Denver, Colo.
KANSAS.—Fort Hays Experiment Station, Hays, Kans.
  State forester, Manhattan, Kans.
OKLAHOMA.—Woodward Field Station, Woodward, Okla.
  Agricultural Experiment Station, Stillwater, Okla.
  Lawton Field Station, Lawton, Okla.
NEW MEXICO.—College of Agriculture, State College, N. Mex.
  Tucumcari Field Station, Tucumcari, N. Mex.
  District forester, Forest Service, Albuquerque, N. Mex.
TEXAS.—State forester, College Station, Tex.

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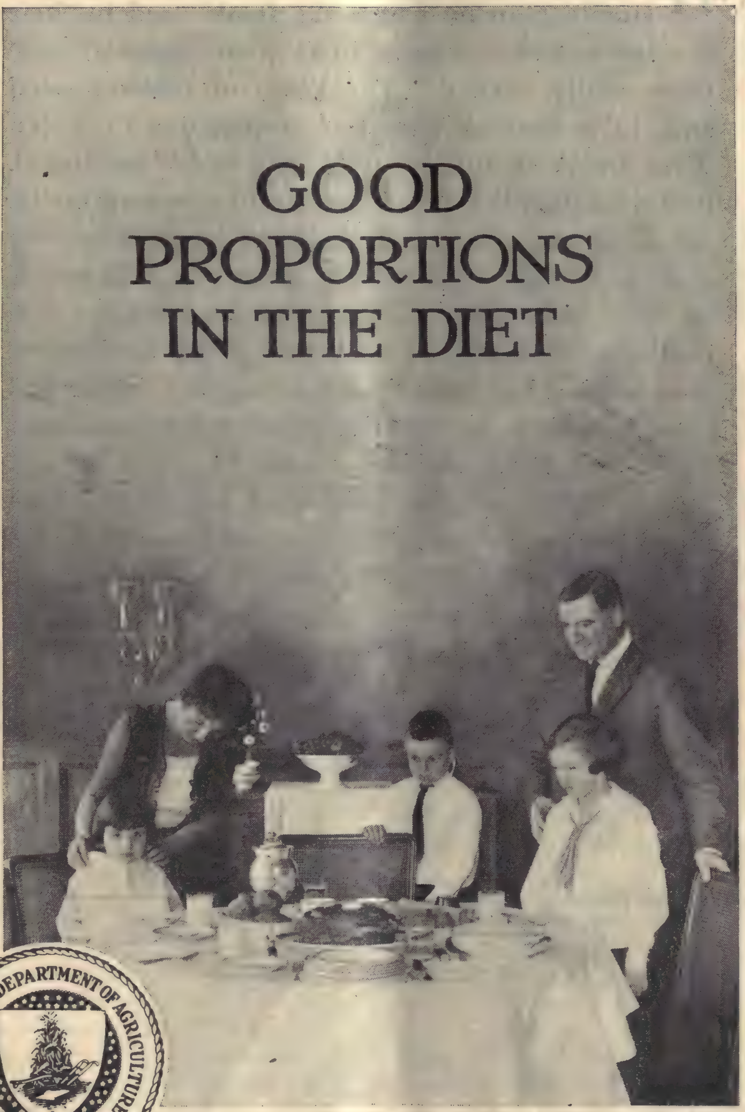
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1313

GOOD PROPORTIONS IN THE DIET



HOUSEKEEPERS often feel the need of some simple plan by which the foods used in their families can be compared in kind and quantity with those really needed. The kinds of foods needed and, in a general way, the proportions in which these foods should be used can easily be stated. But since families differ greatly in size and in the ages and occupations of their members it is very difficult to state the amounts needed in such a way as to be universally helpful. In this bulletin proportions are discussed in terms of the amount of food needed by a family consisting of a father and a mother, both doing active but not hard muscular work, and three children under 12 years of age. Such a group of people is what has come to be known as the "average," or "census," family and is here taken as the starting point for considering the needs of other families, smaller as well as larger, and engaged in more active and less active work.

This bulletin supersedes Farmers' Bulletin 1228.

Washington, D. C. **Issued March, 1923.**

GOOD PROPORTIONS IN THE DIET.

CAROLINE L. HUNT, *Specialist, Office of Home Economics, States Relations Service.*

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KINDS OF FOODS NEEDED.

THE NUMBER of different food materials available in most parts of the United States is very great and is constantly increasing as a result of improved methods of agriculture, the invention of new manufacturing processes, the introduction of foreign food plants, and the cultivation of wild varieties. There is no one of all these many foods that can not be introduced into the diet in such a way as to contribute to its wholesomeness or its attractiveness, but the number of different kinds of food needed is very small. Many food materials, the various cereals, for example, are practically interchangeable in the diet. In fact, most of the common foods may, as suggested in other publications of this department,[1] be classified into five groups according to their composition and uses, namely, (1) vegetables and fruits, (2) meat, milk, and other foods depended on for complete, or efficient, protein, (3) cereals, (4) sugar and sugary foods, and (5) fats and fat foods.

A meal, a day's ration, or a weekly food supply made up from representatives of all these five groups is likely to provide all the substances required to make the diet wholesome and attractive, and for this reason the classification should serve as a guide in the selection of foods and the planning of meals. It should be of some help, too, in comparing the cost of different foods, for it separates foods that have little or nothing in common, and brings together under one head food materials that are enough alike to be compared in and the farmer must not expect to secure any great amount of wood from it for farm use, as removing much large material or even trimming the branches may lessen or even destroy the protective value of the windbreak.

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[1] Farmers' Buls. 717, Food for Young Children; 808, How to Select Foods: I. What the Body Needs; 817, How to Select Foods: II. Cereal Foods; 824, How to Select Foods: III. Foods Rich in Protein; and U. S. Dept. Agr. Bul. 975, Food Values: How Foods Meet Body Needs.

In addition to the shelter belt for the protection of the farm buildings, garden, orchard, and stock-feeding yards, every farm should have a wood lot for raising fuel, posts, and perhaps a limited amount of poles and saw-log material. The high price of coal and the low value of farm products at times have caused many farmers in portions of the Great Plains, especially those situated a considerable distance from the railroad, to burn corn. During periods of hard times some have been obliged to use cow chips for fuel as the early settlers used buffalo chips. (Fig. 1.) The continuation of these practices is for the most part unnecessary, since the comparative ease with which poplars or other fast-growing species can be grown in much of the region makes it possible for farmers to have a supply of wood for fuel. (Fig. 2.) If good care is given the trees, they will develop rapidly. Some will have to be cut out to prevent harmful crowding. The material thus removed will furnish posts and fuel. When the plantation is still older, larger and more valuable products may be harvested, such as small telephone poles for farmers' lines, small timbers, and miscellaneous material for general use around the farm.

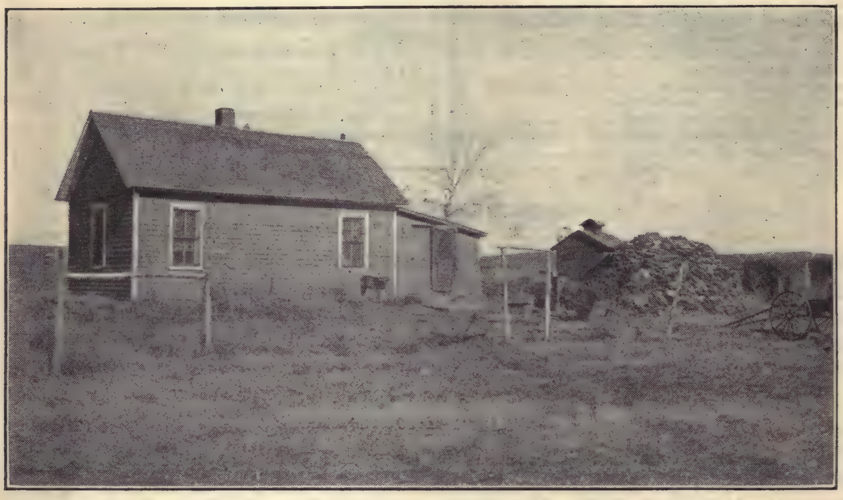

FIG. 1.—Ranch house in western Nebraska. No comfort; cow chips for fuel.

THE GREAT PLAINS.

The Great Plains extend from about the 99th meridian west to the foothills of the Rocky Mountains. They include roughly the western half of North and South Dakota, Nebraska, Kansas, Oklahoma; the "panhandle" of Texas as far south as the southern line of New Mexico; and the eastern Plains region of Montana, Wyoming, Colorado, and New Mexico. (Fig. 3.) This embraces approximately

400,000 square miles, or a territory equal to all of New England and the Atlantic Coast States, including Florida. The elevation of the Great Plains varies from 1,300 feet above sea level on the Missouri River in South Dakota to about 7,000 feet in southeastern Wyoming and on the Arkansas divide in Colorado.

CLIMATE.

The climate is characterized by a light rainfall and a comparatively high wind velocity with its accompanying high rate of evaporation. Wind, in fact, is the limiting factor in tree growth in the higher portions of the Plains, particularly in southeastern Wyoming. The northern Plains are subject to extremes of temperature both in summer and winter, and hail storms are common throughout the region. Taken altogether, the climate is so very difficult that trees can be raised on dry-land sites only with special care.

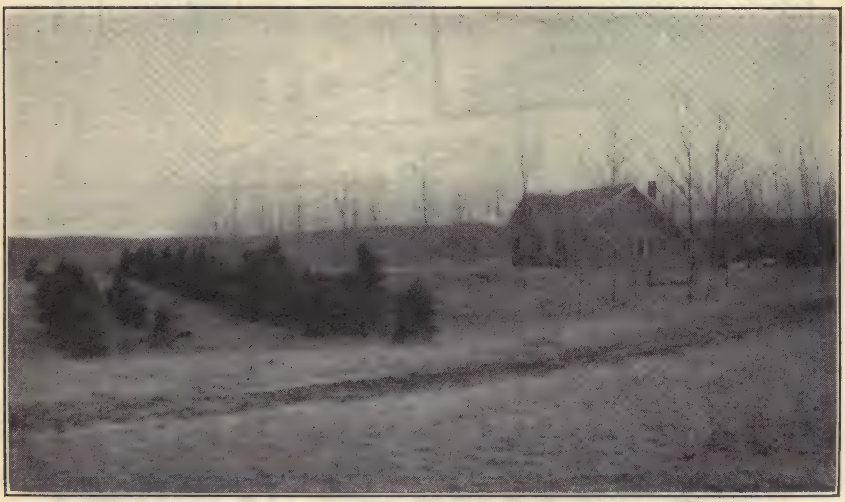

FIG. 2.—Carolina poplar and western yellow pine planted. Thomas County, Nebr. Comfort arrived; wood for fuel on the way.

SOILS.

The types of soil that characterize this area range from pure sand in the sand hills of Nebraska, through sandy loam, loess, silt, and clay loam to heavy gumbo clay and shales. In some sections an impervious layer of cemented gravel or heavy clay a few feet beneath the surface prevents the ready passage of soil moisture to or from the lower depths. This, of course, would limit the root system of the tree to the upper levels of the soil and make it dependent almost wholly on rainfall for water. There are also some localities where alkaline salts are present in the soil to such an extent as to prevent the growth of trees.

SECTIONS.

For the planting of trees, this region may be divided into the northern, central, and southern Great Plains. The northern Great Plains includes roughly the western parts of North and South

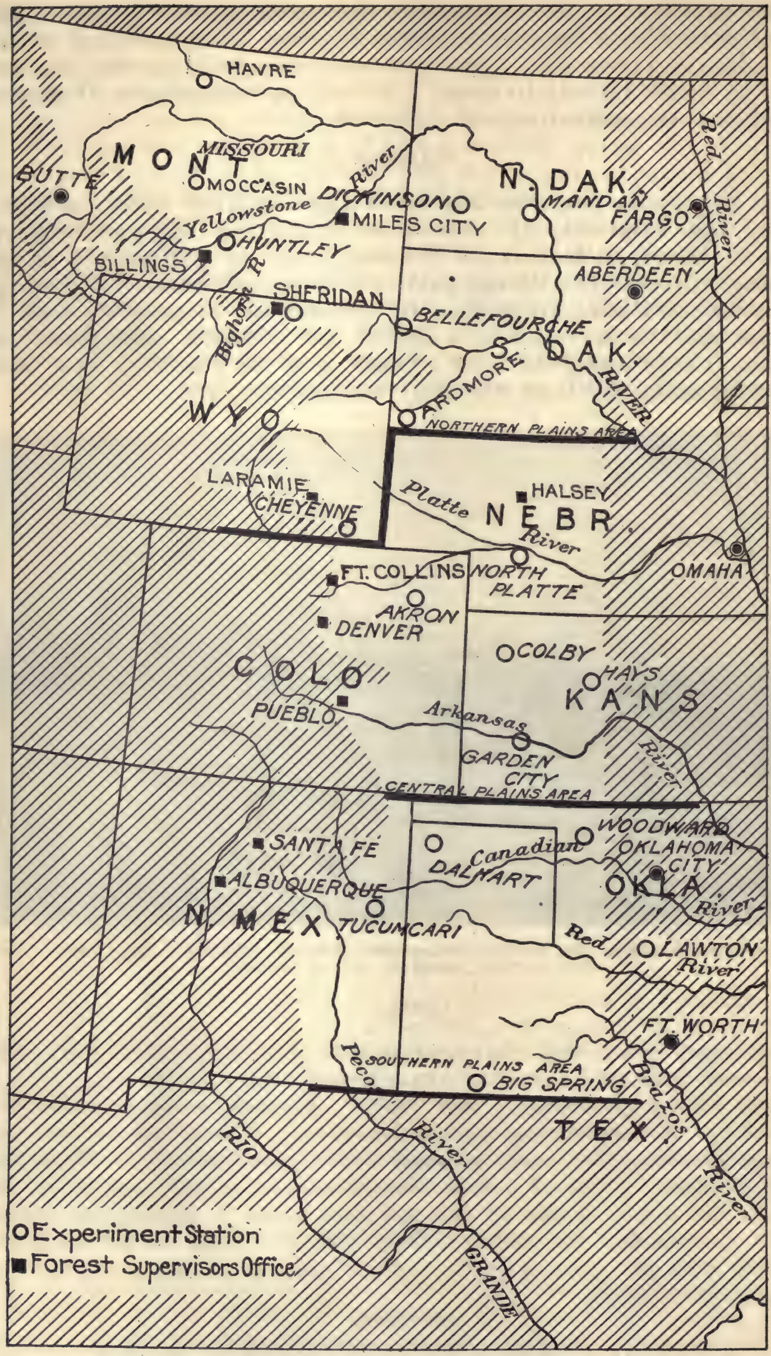

FIG. 3.—Sketch map of Great Plains.

Dakota and the plains sections of Montana and Wyoming. The central Great Plains includes western Nebraska and Kansas and eastern Colorado. The southern Great Plains comprises western Oklahoma, western Texas to the southern boundary of New Mexico and eastern New Mexico.

SPECIES RECOMMENDED.

The trees adapted to these sections are presented in two groups in the approximate order of their desirability—those which are actually known to be hardy and those which are semihardy in certain districts or entirely hardy under irrigation. Of course it is not possible thus arbitrarily to divide the region by definite lines, as the range of any desirable tree overlaps from one section to the other.

HARDY TREES.

A list of hardwoods and conifers follows:

Northern Great Plains. (Western North and South Dakota, eastern Montana, and Wyoming.)	Central Great Plains. (Western Nebraska and Kansas, eastern Colorado.)	Southern Great Plains. (Western Oklahoma and Texas, eastern New Mexico.)
Hardwoods:	Hardwoods:	Hardwoods:
Green ash.	American elm.	Russian mulberry.
Box elder.	Honey locust.	American elm.
American elm.	Hackberry.	Honey locust.
Northwest poplar.	Green ash.	Green ash.
Caragana (Siberian pea).	Russian olive.	Russian olive.
Russian olive.	Cottonwood (common and lance-leaf).	Cottonwood.
Buffalo berry.	Poplar (Norway and Carolina).	Osage orange.
Chokecherry.	Chinese elm.	Hackberry.
Wild plum.	Buffalo berry.	Black walnut.
Conifers:	Willows (laurel-leaf, Russian golden, white).	Caragana.
Black Hills spruce.	Box elder.	Chinese elm.
Jack pine.	Osage orange.	Soapberry.
Colorado blue spruce.	Russian mulberry.	Conifers:
Red cedar.	Chokecherry.	Chinese aborvitæ.
Western yellow pine (bull pine).	Wild plum.	Red cedar.
Scotch pine.	Caragana.	Scotch pine.
	Black walnut.	
	Conifers:	
	Jack pine.	
	Western yellow pine.	
	Scotch pine.	
	Black Hills spruce.	
	Red cedar.	
	Chinese arborvitæ.	
	Colorado blue spruce.	

A further grouping of the hardy trees shows the uses to which they are best adapted. Most of the species listed are suitable for windbreaks, but many of them will not produce poles or lumber. The ideal shelter belt will contain a mixture of species, with the low-branching, compact species on the windward side and the larger and usually longer-lived trees on the lee.

The low-branching, compact species most suitable for windbreaks are Caragana (Siberian pea tree), Russian olive, buffalo berry, Russian mulberry, wild plum, and chokecherry. Most of the conifers listed, and particularly red cedar, Black Hills spruce, and Chinese arborvitæ, make very effective windbreaks.

For posts and small telephone poles, green ash, American elm, honey locust, osage orange, red cedar, jack pine, Scotch pine, and western yellow pine are suggested, but when used for these purposes, a preservative treatment with creosote is advisable for all these species except osage orange and red cedar.

Any of the species can be used for fuel. Box elder is usually of such poor form that it is not suitable for any other purpose.

Of the species adapted to the Great Plains, cottonwood, American elm, western yellow pine, and Scotch pine will make the best lumber.

SEMIHARDY TREES.

In the Great Plains region there are many trees that are hardy in certain sections but are of no value in others. There are also trees that are hardy on the eastern edge of the region that have been planted but little, if any, in the more severe regions farther west. These are listed in the following paragraph, and it would be well to try them out, at least in towns where plenty of water is available or on irrigated projects.

In the northern Great Plains (North Dakota, Montana, and northern South Dakota), linden or basswood, black walnut, Chinese elm, lance-leaf cottonwood, and Tartarian maple; in southern South Dakota, honey locust, hackberry, Russian mulberry, white willow, Russian golden willow, laurel-leaf willow, and soft maple. In the central Great Plains, the foregoing willows, osage orange, soft maple, Kentucky coffee tree, catalpa, sycamore, and white ash. In the southern Great Plains, catalpa, sycamore, ailanthus, Arizona ash, Arizona cypress, and New Mexico locust.

TREE DESCRIPTIONS.

A description of the more important species follows:

HARDWOODS.

Green ash (*Fraxinus lanceolata* Borkh.).—The green ash is found over practically the entire Great Plains, growing naturally on upper levels of the valleys and often pushing far up open valleys or ravines to the prairie levels. It grows very well under cultivation and is one of the most desirable trees for either shelter belts or woodlots. (Fig. 4.) It responds well to good treatment; in fact its value as a producer of useful material is largely dependent upon the care given it. In sections where it is attacked by a borer, it should be grown in mixture with some other species. It grows well on nearly all kinds of soil except sand and gravel and those soils that are heavily alkaline. In valleys, under most favorable conditions, it may grow an inch in diameter in two years; but in neglected upland groves it sometimes requires nine years to make that much growth. In plantations at North Platte, Nebr., green ash has attained an average height of 20 feet in 15 years.

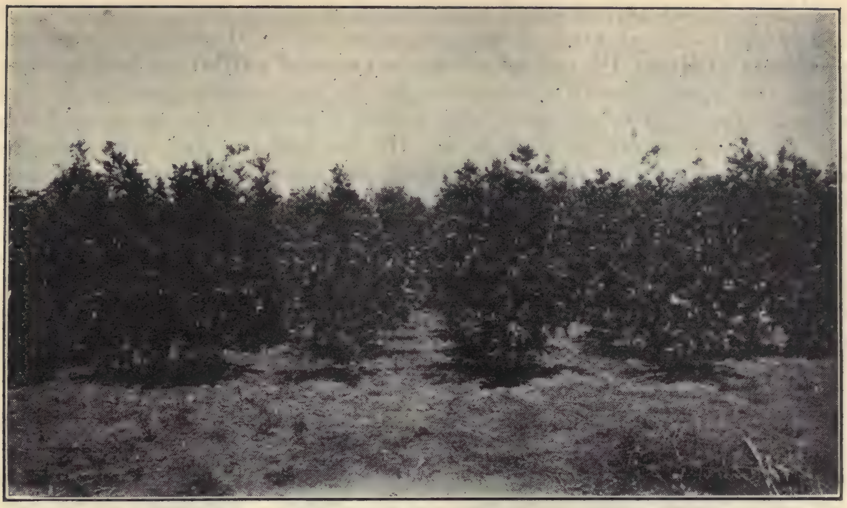

Fig. 4.—Green ash plantation 4 years old. Ardmore, S. Dak.

American or white elm (*Ulmus americana* L.).—The American elm is native to the Great Plains except in central Montana, Wyoming, Colorado, New Mexico, and western Texas. (Fig. 5.) It is, however, hardy to the foothills of the Rocky Mountains and is one of the best trees for shelter belts, woodlots, and street plantings on either upland or bottom sites, on dry or irrigated land. American elm thrives best in a heavy soil, but adapts itself fairly well to a sandy loam. Owing to its early flowering and seeding habit, the flowers or seeds are frequently killed by late frosts, and this often makes it impossible for several years in succession to secure local seed on the Plains.

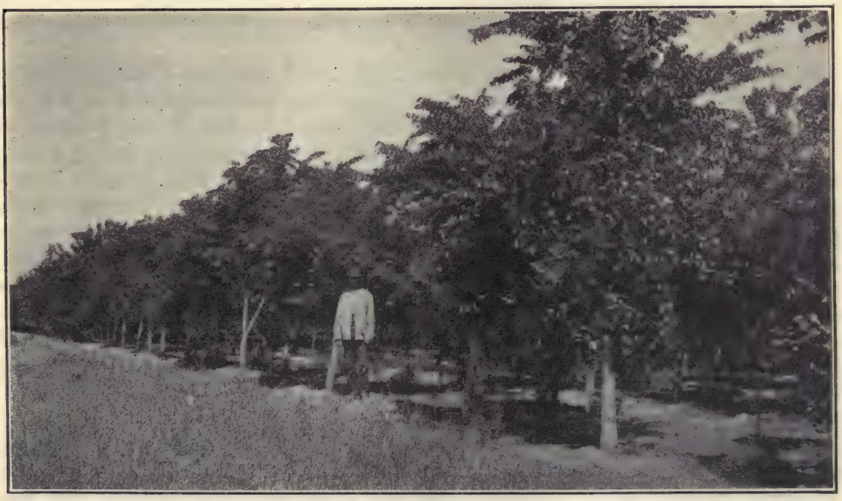

Fig. 5.—White elm plantation 9 years old. North Platte, Nebr.

Honey locust (*Gleditsia triacanthos* L.).—The honey locust ordinarily may be planted from southern South Dakota southward through the Great Plains, although on exposed situations in northern Nebraska it occasionally freezes back. It has made a good record as a hardy, rapid-growing, general-purpose tree and is recommended for planting in that region. (Fig. 6.) It has rather light, open foliage and in shelter-belt plantings should be mixed with more densely foliaged trees. A large proportion of the trees have good form, and they are strong in stem and branch and not often injured by wind or ice storms. The tree is well adapted to heavy soils on uplands as well as on bottom lands and irrigated sections. Its rate of growth is only moderate, but is maintained for many years. Honey locust planted on an upland situation in northwestern Kansas has reached a diameter of 5.7 inches and a height of 24 feet in 20 years.

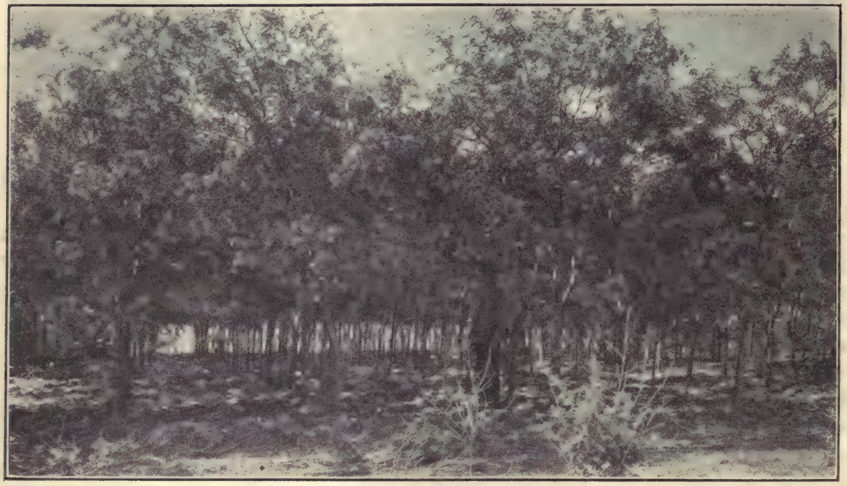

FIG. 6.—Honey locust plantation 9 years old. North Platte, Nebr.

Russian mulberry (*Morus alba tatarica* Loud.).—This mulberry has proved to be of greater value than the native varieties of the more central and southern States. On upland sites it has proved to be hardy as far north as southern South Dakota and to make excellent growth as a hedgerow or windbreak. Since this tree is somewhat variable as to hardiness, only proved hardy planting stock, preferably from locations north of those where the planting is to be made, should be used. Mulberry hedges and shelter belts are common in the central and southern Great Plains. (Fig. 7.) The tree is particularly desirable for planting around an orchard, as the birds will not bother fruit trees if they can feed on mulberries. The leading shoots frequently winterkill for a foot or two, and this increases the natural tendency of the tree toward a low, bushy growth. It branches diffusely near the ground, and only severe pruning can make it develop a respectable trunk. When well developed it makes good fence posts. An 18-year-old Russian mulberry hedge in southwestern Kansas will yield nearly 200 posts from a section 400 feet long.

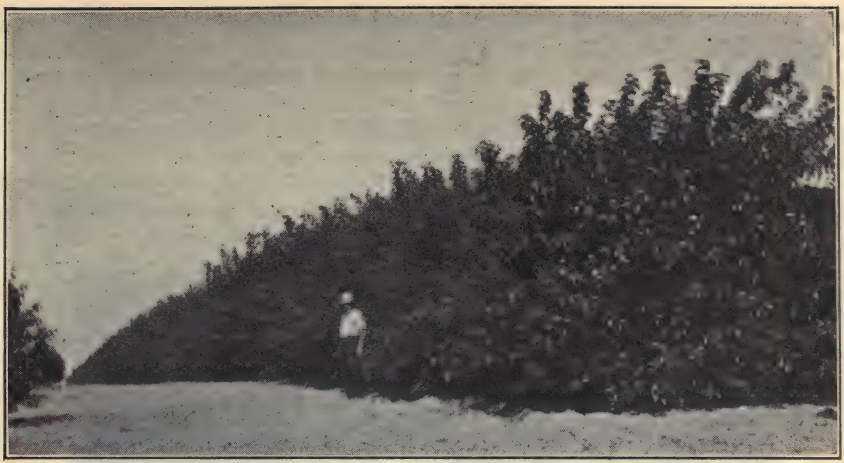

Fig. 7.—Russian mulberry windbreak 6 years old. Woodward, Woodward County, Okla.

Hackberry (*Celtis occidentalis* L.).—The range of the hackberry includes the eastern Dakotas, and extends through Nebraska to Colorado, and southeast to the Panhandle of Texas. It has not proved entirely hardy in the northern Plains and is not recommended for plantings there. In general appearance it resembles the elm and would serve the same purpose in shelter belt, woodlot, or town plantings. It may be planted on both sandy and heavy soils and also on bottom lands. Grown in combination with American elm at the North Platte (Nebr.) Experiment Station it equals the elm in height at the end of 16 years.

Box elder (*Acer negundo* L.).—This tree, also called ash-leaved maple and Manitoba maple, is without doubt the hardiest of the maples, growing in valleys to the Rocky Mountains. Because of its low-branching habit it is planted in great quantities throughout the northern and central plains for shelter-belt purposes. (Fig. 8.) It

Fig. 8.—Norway poplar and boxelder plantation. Northern Montana.

is one of the best trees for such upland plantings, but is liable to suffer some slight injury the first winter or two after it is set out. After becoming acclimated it makes good growth. It is not to be considered as a first-class woodlot tree, although a 27-year-old plantation at Great Bend, Kans., has attained an average diameter of 7 inches and a height of 25 feet.

Caragana (*Caragana arborescens* L.).—This shrub, often called Siberian pea tree, makes its best growth in the northern Plains on more or less heavy upland soils. It does not do well in sand or gravel or in low, wet situations. No attempt should be made to train it into a tree, as its natural form is shrubby. It is ideal for hedges and as low-growing trees on the outside of shelter belts. It is also used for group plantings about buildings or on lawns. In some sections of the northern Plains it is severely attacked by blister beetles.

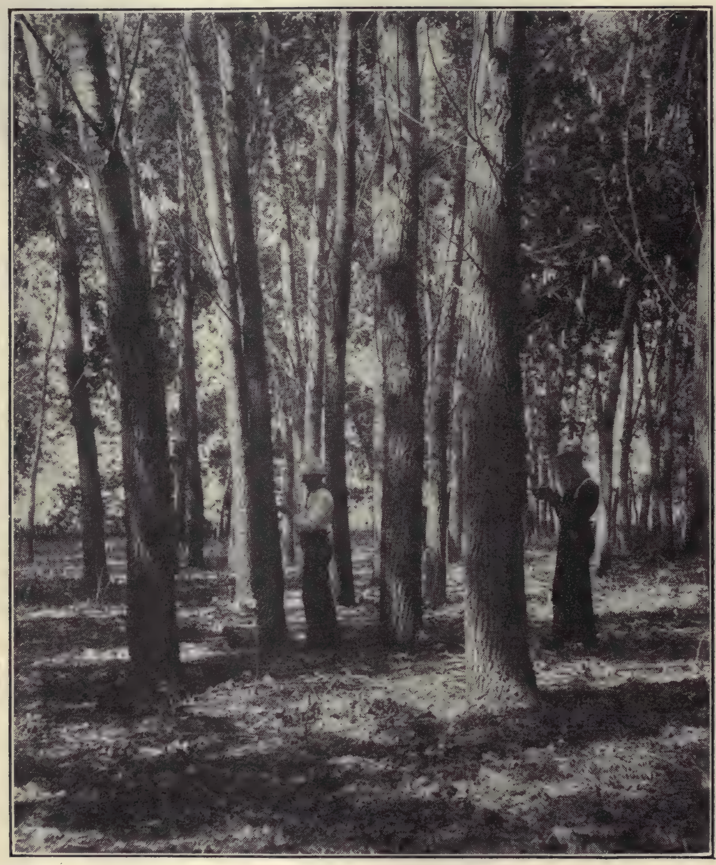

FIG. 9.—Cottonwood plantation 24 years old. Buffalo County, Nebr.

Russian olive (*Elæagnus angustifolia* L.).—The Russian olive is one of the best trees to plant for shelter-belt purposes throughout the Great Plains. It is thorny and usually bushy, although in some favorable locations it grows as high as 40 feet. When planted fairly close the trees will keep out live stock. It does well in dry land and in irrigated sections on both upland and bottom land, except in low, wet situations. It is not a woodlot tree. Its unique silver-green foliage adds wonderfully to the appearance of any combination in which it is planted.

Cottonwoods and poplars (*Populus* spp.)—Cottonwoods and poplars are fast-growing trees and are common over the entire region, though of several species and nursery varieties. (Fig. 9.) Where quick results are wanted, they are good trees to plant, provided the proper species or varieties are used. They make excellent additions to shelter belts and serve many purposes in woodlot plantings.

In the northern Plains the northwest poplar is the best to plant. (Fig. 10.) It is native to North Dakota, seems adapted to all kinds of soils, and, if well cultivated, has proved able to endure both the winter cold and the summer drought even on upland soils.

The common cottonwood will not always succeed in upland planting, but with cultivation some excellent plantations have been raised on uplands. In general, it is not recommended for dry situations. On sites favored with moisture, even at a considerable depth, it will make good growth. It has been extensively planted throughout the northern and central Plains, particularly on tree claims, and considerably in the southern Plains and the eastern parts of the northern Plains. (Fig. 11.) However, it does not do well on the uplands of the northern Plains west of the Missouri River. The nursery varieties, Norway poplar and Carolina poplar, are entirely hardy in southern South Dakota and in Nebraska. Cottonwood is short-lived, but on account of its rapid growth quickly furnishes fuel and shelter, and for these purposes it has been almost indispensable to many settlers. On sandy loam soil in southwestern Kansas, cottonwood has attained in 28 years a diameter of 18 inches at 4 feet from the ground and a height of 70 feet.

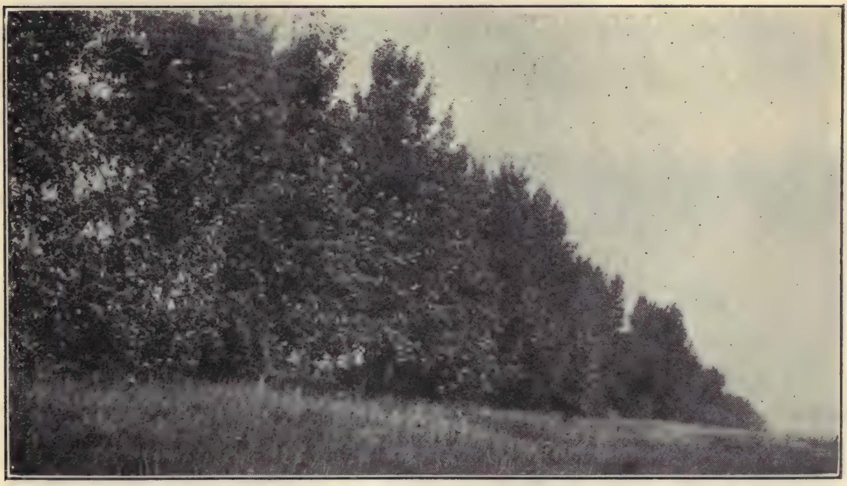

FIG. 10.—Northwest poplar. Wells County, N. Dak.

The lance-leaf cottonwood of the eastern Rocky Mountain slope is also a desirable tree for the western part of the northern and central

Plains. "Canadian poplar" is one of the Russian poplars which has been extensively planted in the northern Great Plains. It is hardy to winter cold and resists the ordinary amount of drought, but is subject to attacks by canker, a disease which soon girdles the tree, generally near the base or at a crotch, and kills that portion above the canker. This disease is quite common on all Russian poplars grown in this region. For that reason they are not recommended for general planting.

Buffalo berry (*Shepherdia argentea* Nutt.).—This low tree or shrub is native to the Great Plains, except Oklahoma and western Texas. It is very hardy and naturally grows in very difficult situations. It responds readily to cultivation and, except on low, wet situations, is recommended for windbreaks when cultivation can be given. It may grow to be 20 feet high under favorable conditions. Where little or no other native fruit is obtainable, the currantlike berries are eargerly sought for household purposes.

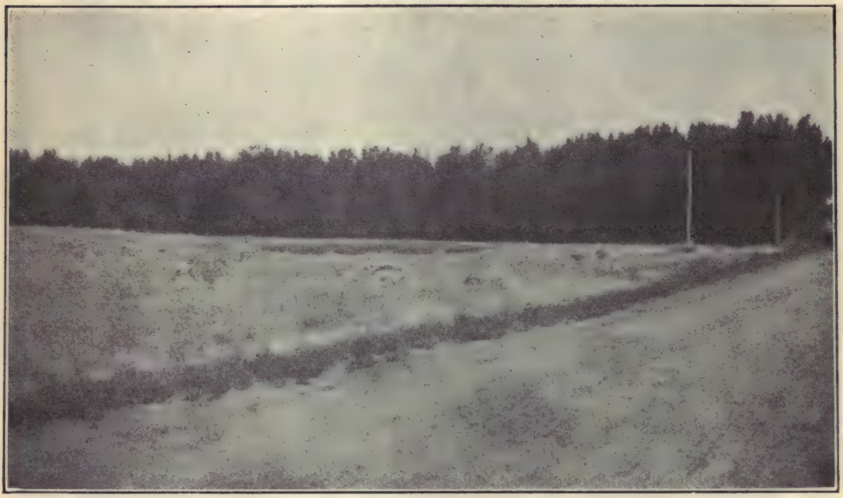

FIG. 11.—Cottonwood timber claim. Trees 35 years old. Steele County, N. Dak.

Osage orange (*Toxylon pomiferum* Raf.).—Osage orange is a very desirable tree for parts of the central and all of the southern Plains for shelter belts, hedgerows, and woodlots. It winterkills in northwestern Nebraska and in eastern Colorado, except in the Arkansas Valley. It is one of the best trees for upland planting in western Kansas and will live even when crowded by the grasses. It is very hardy and resistant to various forms of tree diseases. It does not make so rapid growth nor become a tree of so good form as the honey locust, but it is unsurpassed for posts, poles, and fuel. A 17-year-old hedge of osage orange near Hays, Kans., averaged 25 feet high and 6.4 inches in diameter. Twenty trees taken consecutively in a row produced 22 stakes and 47 posts. Another hedge 30 years old in western Kansas, from which many posts had been cut, it was found upon examination, would still yield from a 500-yard section 1,000 posts, some of them 12 inches in diameter. These posts are known to the lumber trade as "bois-d'arc," and are kept in stock by many lumber dealers in the southern Plains.

Chinese elm (*Ulmus pumila* L.).—The Chinese dry land elm, which was introduced by the Department of Agriculture in 1908, has grown well on heavy or light soils wherever tried, though apparently preferring the heavier soils. It is a fast-growing tree of dense foliage and inclined to low branching. It promises well for shelter-belt, woodlot, and lawn planting. A suspicion has arisen that there may be two forms or strains of this elm, one of which, coming from a different locality in China, is proving hardier than the other. In the northern Plains the trees of this species so far tried have not been entirely hardy, but under irrigation in South Dakota and in the central Plains without irrigation the species has proven very satisfactory.

Willows (*Salix* spp.).—The willows have not been found suitable for upland plantings in the northern Plains, though in the central Plains they have done fairly well, particularly on the banks of reservoirs. Their use is probably limited to the more moist situations. The common diamond willow has not proved very desirable when grown on upland, but it makes good growth along the bottoms. The laurel-leaf and Russian golden willows have been extensively tried out in the northern Plains and have often proved unable to endure either the cold of winter or the summer drought. They are not generally recommended for upland planting north of southern South Dakota, except on the eastern limits of the Plains. The same recommendations can be made as to planting the white willow.

Chokecherry (*Prunus virginiana* L.).—The chokecherry grows naturally in the valleys and river bottoms over practically the entire Great Plains region. It has been tried in a few places on the uplands in the northern Plains and has proved well worth planting for shelter-belt purposes. Except that it is not well adapted to very sandy or to low, wet situations, it is not particular as to soil, but it needs good care. It produces suckers profusely, and this is sometimes an objection to its planting.

Wild plum (*Prunus americana* Marsh.).—The wild plum is native over the Great Plains. Where planted as seedlings in shelter belts or woodlots it makes good growth and often produces fruit in five years. While it has not been generally planted, it is well worth trying out.

Catalpa (*Catalpa speciosa* Warder).—Catalpa will thrive under the proper conditions in western Kansas, Oklahoma, and Texas. It is not well adapted to the most rigorous sites, but it has been raised successfully on sandy loam soils where there is permanent water at a depth of 10 to 20 feet. It has been recommended by the Woodward Field Station in Oklahoma for low, wet bottoms where extensive drainage will be necessary before crops can be raised. (Fig. 12.) On such land, unless the soil is alkaline, catalpa will make a rapid growth and produce an abundance of posts. There are records of catalpa plantations in central and western Kansas that have produced 3,000 posts per acre and better in 14 to 18 years.

Black walnut (*Juglans nigra* L.).—Black walnut has been planted in different sections of the Plains as far north as Mandan, N. Dak.

Although it has proved hardy under severe conditions, it has thrived only under favorable conditions. There is a tendency for the trees to die out gradually in upland plantations. Black walnut winterkills in most parts of eastern Colorado, except in towns and cities and within 30 miles of the foothills. Only by planting on protected sites, preferably in valleys, by careful cultivation, and by the use of seed from hardy trees can black walnut be adapted to most parts of the Great Plains. Although this species offers possibilities for planting under favorable conditions in the central and southern Plains, it can not be recommended as a tree for general planting. It

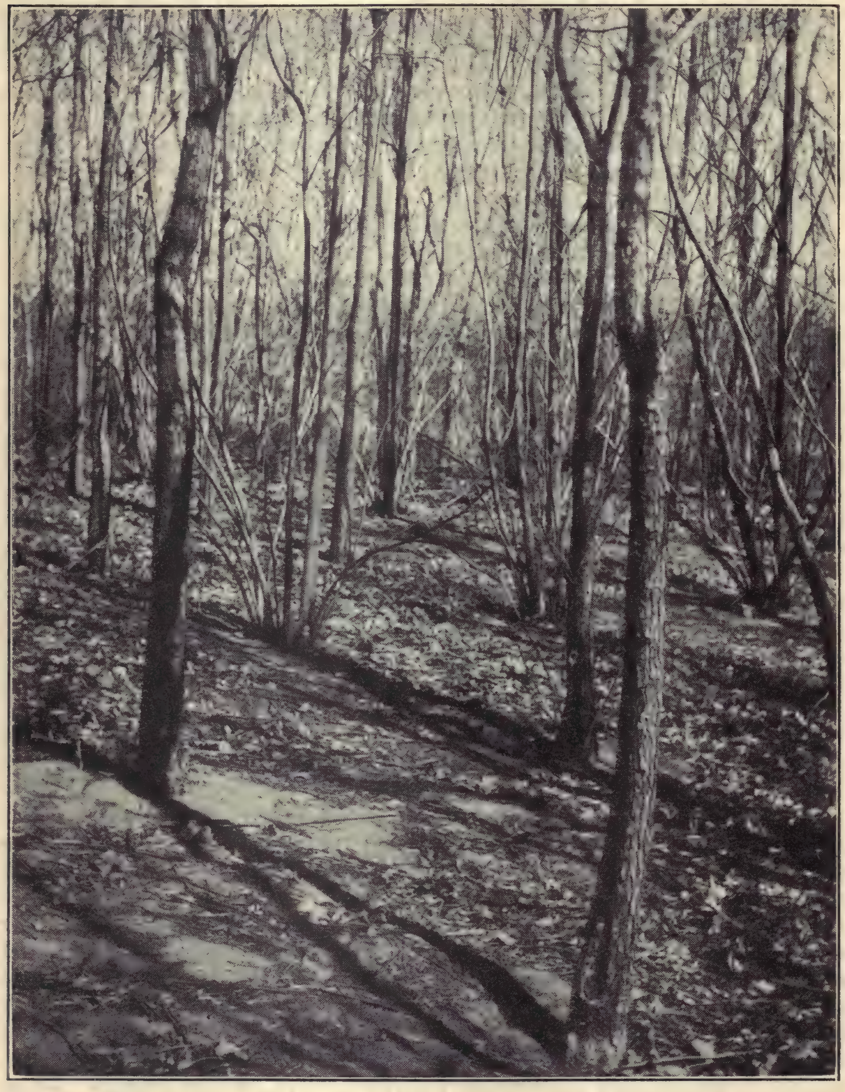

FIG. 12.—Hardy catalpa plantation on low ground. Woodward County, Okla.

should be planted in more or less open groves or woodlots. In southern South Dakota it has borne nuts after 8 or 9 years.

Soapberry (*Sapindus drummondii*).—Drummond's soapberry occurs naturally in river valleys and on hillsides, often on moist unfavorable sites, from southern Missouri through Oklahoma and into New Mexico. It appears to be free from injurious insects. It is not a rapid-growing tree, but often reaches a height of about 40 feet. This tree has been only occasionally planted in the southern Plains, but it is believed to be very hardy, and should make a good tree for that region. It has been successfully planted as an ornamental tree at Woodward, Okla., and at other towns in the southern Plains.

Silver or *soft maple* (*Acer saccharinum* L.).—Silver or soft maple has been extensively used in the central Plains principally for ornamental and windbreak planting. It matures at an early age, the wood is decidedly brittle, and large branches are often broken off in heavy windstorms. As silver maple is not very drought-resistant, it can be recommended only for valley planting where the roots will eventually go down to water. In such places it will quickly furnish shade and shelter.

CONIFERS.

Fewer conifers or evergreens than hardwood species are adapted to the Plains. None of these will withstand alkaline soils. They require more care, and the loss may be heavier; but those that are adapted to the region make more permanent and effective windbreaks than the hardwoods. It is best to prepare for conifers by setting out a belt of hardwoods of some of the species just discussed. After these hardwoods are several years old and are making good growth, the conifers should be set out in a belt on the leeward side and about 20 feet from them. The conifers will then not be subjected to the root competition of the hardwoods; they will receive protection from the prevailing winds; and they will be covered during the winter by the snow that drifts in to the leeward of the hardwoods.

Jack pine (*Pinus divaricata* DuMont de Cours).—A native of the Lake States, jack pine has proved very adaptable to the sandy and light loam soils of the northern and central Great Plains. It does not thrive on heavy clay soils or in low, wet situations. It does well planted either as a shelter belt or woodlot and is recommended for general planting. It is a very rapid-growing conifer, averaging under favorable conditions a foot a year for 40 years. Jack pine has been planted extensively, particularly by the Forest Service, in the Nebraska sandhills, where it adapts itself very readily to the conditions and makes rapid growth. Trees that have been planted 19 years now average 25 to 30 feet in height and are large enough for posts. A grove of jack pine planted 2 feet apart on a sandhill in Holt County, Nebr., in 1921, produced in 28 years approximately 36 cords of 4-foot wood per acre. Although the trees were planted so densely that they retarded each other's development, trees large enough to produce 742 fence posts and 58 small telephone poles per acre had developed. (Fig. 13.)

Western yellow pine (*Pinus ponderosa* Laws).—The western yellow or bull pine is native to the southeastern part of Montana and western North Dakota and south through the Black Hills to northern Nebraska and eastern Wyoming, Colorado, and New Mexico. Although it has been comparatively difficult by planting to obtain suitable stands of this tree in sections of Montana, North Dakota, and South Dakota, it has done very well in Nebraska and Colorado. It grows more slowly than either the jack or Scotch pines, but, once established, is very hardy. This tree has been extensively planted in the Nebraska sand hills by the Forest Service, where, after becoming thoroughly established, it has made an excellent growth, although handicapped to some extent by an insect, the pine-tip moth.

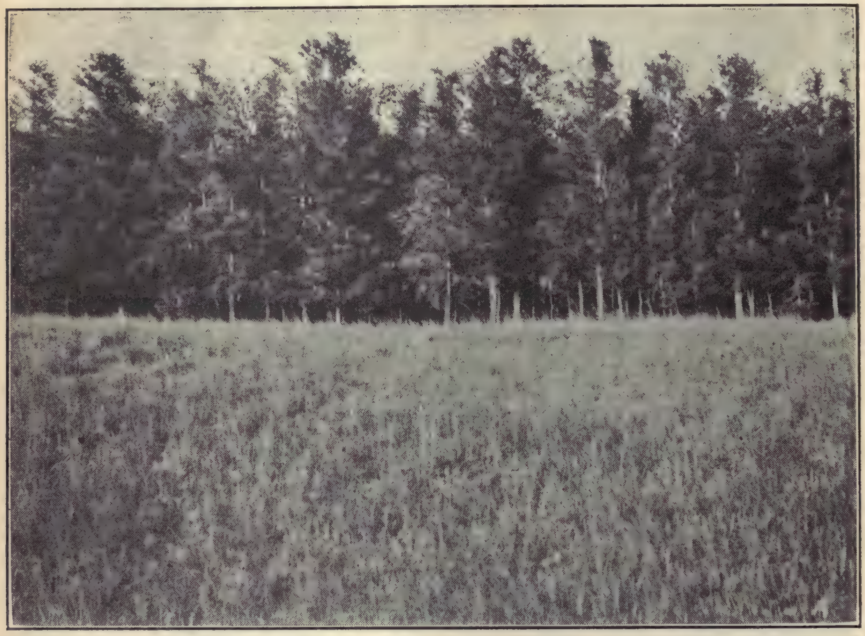

FIG. 13.—Jack pine plantation 30 years old. Holt County, Nebr.

A western yellow-pine plantation established in 1888 in Rock County, Nebr., with 3-year-old forest-pulled seedlings spaced 11 feet apart, showed after 31 years a total volume of 2,339 cubic feet, or approximately 30 cords of 4-foot wood per acre. The average diameter 4½ feet above the ground was 10.1 inches, and the average maximum height was 45 feet. There were 113 trees per acre averaging 11.6 inches in diameter and capable of producing two railroad ties each. (Fig. 14.)

Scotch pine (*Pinus sylvestris* L.).—The Scotch pine is a very hardy tree and should make good growth in both shelter-belt and woodlot plantings. It does not make as rapid growth at the start as jack pine, but passes it within 10 years. It may be planted with a fair likelihood of success in most parts of the Great Plains region, except, perhaps, on low, wet situations. It is preferable to plant only the Riga or northern Europe variety, because of its more rapid growth and better form. (Fig. 15.)

Chinese arborvitæ (*Thuya orientalis* L.).—The Chinese arborvitæ is recommended for general shelter and lawn planting for Kansas and southward, and for irrigated sections in Nebraska. Unlike the American arborvitæ, it thrives on heavy upland or limestone soils. It is not a large tree, but its small size is more than compensated for by its hardiness and luxuriant growth. As it is an introduced tree from China, little is known concerning its behavior in old age. This tree is not considered suitable for woodlot plantings.

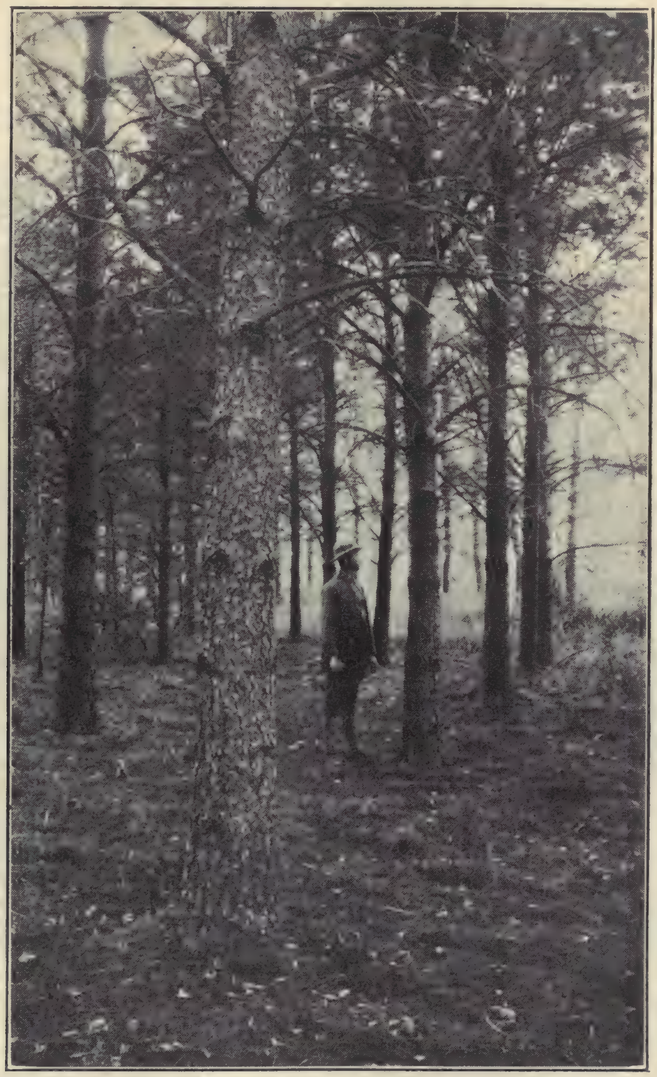

Fig. 14.—Western yellow-pine plantation. Trees 10 inches in diameter. Rock County, Nebr.

Cedars (*Juniperus virginiana* L. and *Juniperus scopulorum* Sarg.).—The red cedars, both eastern and western varieties, are well worth planting over the entire Great Plains. They are hardy under severe conditions and are comparatively easy to transplant from their native sites. They form a very effective shelter belt both winter and summer. Some objections are raised to the cedars because of the presence of the "cedar-apple" fungus, a disease which also affects apple trees in the immediate vicinity. As orchards in the

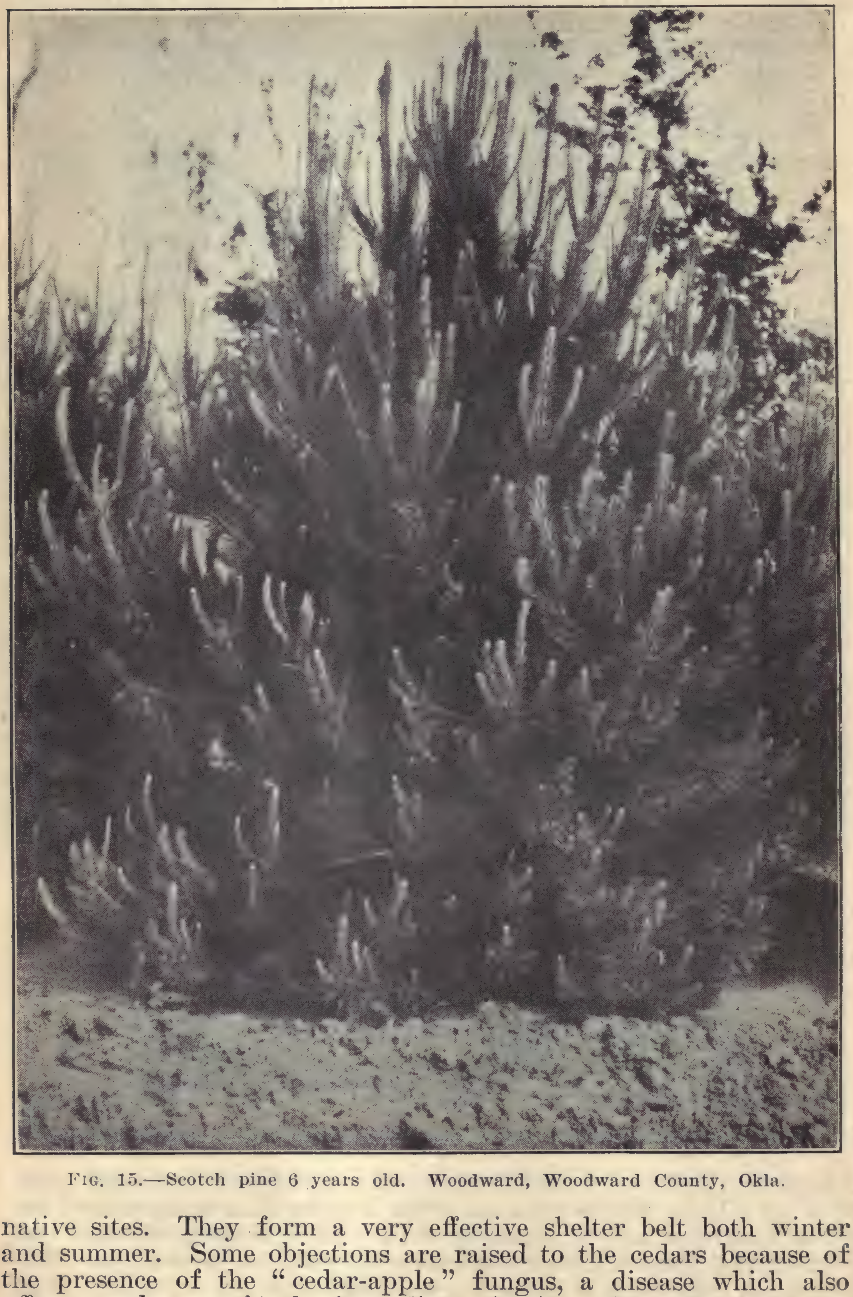

FIG. 15.—Scotch pine 6 years old. Woodward, Woodward County, Okla.

high plains are very scarce and not likely to be common for some years, this objection is not a serious one. According to Prof. B. O. Longyear, of the Colorado Agricultural College, the disease coming from cedar apples on *J. scopulorum* does less harm to fruit trees than when it is transmitted from *J. virginiana.* Scopulorum is the handsomer tree in Colorado and is called " silver cedar " by nurserymen.

Black Hills spruce (*Picea canadensis* B. S. P.).—The Black Hills variety of the white spruce is recommended for general shelter-belt planting in the northern Great Plains and in Nebraska. It makes a fairly rapid growth and is extremely hardy.

Colorado blue spruce (*Picea parryana* Sarg.).—The Colorado blue spruce is native to parts of Wyoming, Colorado, Utah, and New Mexico. When planted on dry-land sites in the northern and central Great Plains, it has generally proved satisfactory. It grows best on the clay soils. It makes slower growth than the Black Hills spruce, but is hardy.

In addition to the above conifers, limber pine (*Pinus flexilis* James) has been successfully planted in several places in eastern Colorado and pinyon pine (*Pinus edulis* Engelm.) in the panhandle of Oklahoma and Texas and in eastern New Mexico.

MIXED PLANTATIONS.

Most of the older plantations in the Great Plains have been made with but a single species. For shelter and woodlot planting, it is sometimes preferable to plant two or more kinds of trees in mixture. Species that have scant foliage may well be combined with those having denser crowns, so as to provide a heavier shade which will kill out the grass and weeds. It may be advisable to plant a long-lived species with one which comes to early maturity. A mixture gives some assurance of a stand of trees even if one of the species is killed or seriously injured by insects or disease.

Tentative conclusions from experimental plots of mixed species indicate that the following combinations should prove successful on soils and in regions adapted to both species:

Boxelder and green ash.
Green ash and American elm.
Northwest poplar and boxelder.
Green ash and honey locust.
Cottonwood or northwest poplar and green ash.
Cottonwood or northwest poplar and silver maple.
Honey locust and hackberry.
American elm and hackberry.

These combinations will do better if the outer rows are planted to Caragana or Russian olive. The dense screen that these species form assists in keeping out the wind, the light, and an encroaching growth of grass.

ORNAMENTAL PLANTING.

Many of the more desirable hardwoods of the Mississippi Valley have been acclimated for planting as lawn, park, and street trees in the towns of the Great Plains region. In towns the trees have more protection from the drying winds, and it is possible to furnish them the needed water. Some towns now prohibit the planting of box-elder, black locust, and female cottonwoods, and recommend such trees as American elm, honey lucust, hackberry, bur oak, black walnut, and American linden. Red oak and pin oak grow successfully in the city of Denver. Conditions vary so much throughout the range of the Great Plains that it is advisable to ask the advice of the nearest State or Government agricultural experiment station before planting any species which has not already been tried in the vicinity and proved hardy.

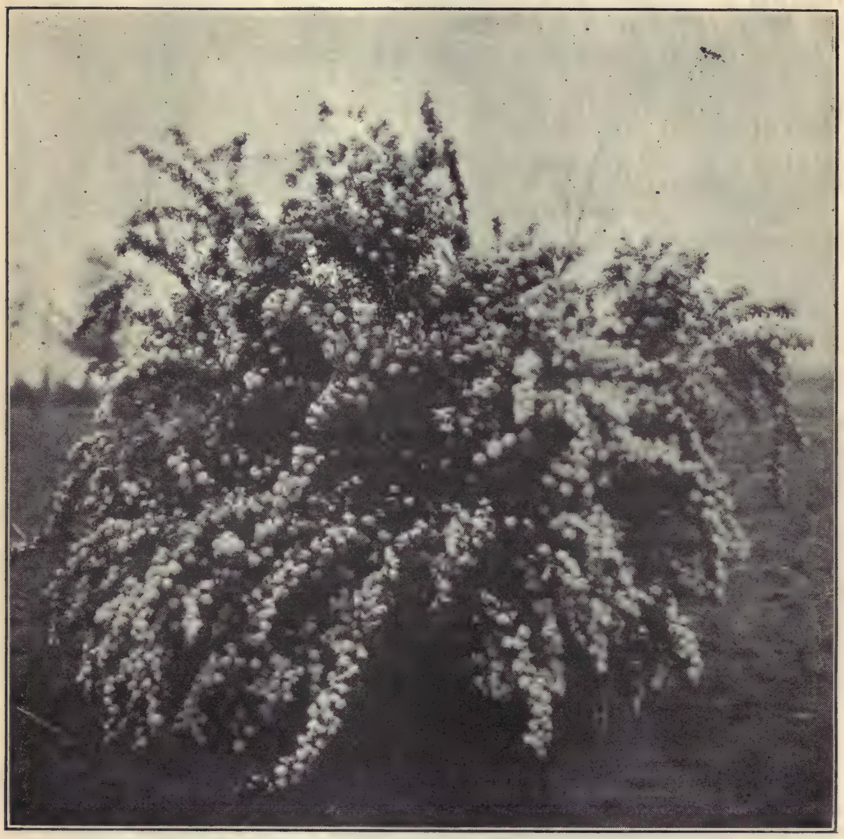

FIG. 16.—*Spiræa vanhouttei.* Woodward, Okla.

Many shrubs have been found hardy for the Great Plains. (Fig. 16.) By planting them in groups around the farmhouse, in corners of the yard, and as screens to conceal outbuildings, the farm home will not only be a more desirable place in which to live, but the value of the farm will be greatly increased.[2]

The following shrubs have been found hardy and drought-resistant for the northern and central Great Plains:

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[2] See U. S. Department of Agriculture Farmers' Bulletin No. 1087, "Beautifying the Farmstead."

Missouri flowering currant (*Ribes aureum*).
Dogwood (*Cornus stolonifera* and *C. sibirica*).
Common lilac (*Syringa vulgaris*).
Himalayan lilac (*Syringa villosa*).
Persian lilac (*Syringa persica*).
Spirea (*Spiræa arguta*, *S. vanhouttei*, and *S. sorbifolia*).
High-bush cranberry (*Viburnum opulus americana*).
Snowball (*Viburnum opulus sterilis*).
Tartarian honeysuckle (*Lonicera tatarica* and *L. morrowii*).

The flowering currant and dogwood occur naturally in many parts of this region and are especially desirable for ornamental plantings. Buffalo berry, Russian olive, and Caragana, previously listed as shelter-belt trees, have also been found valuable for hedges and ornamental planting.

The following list of hardy shrubs is recommended for the southern Plains:

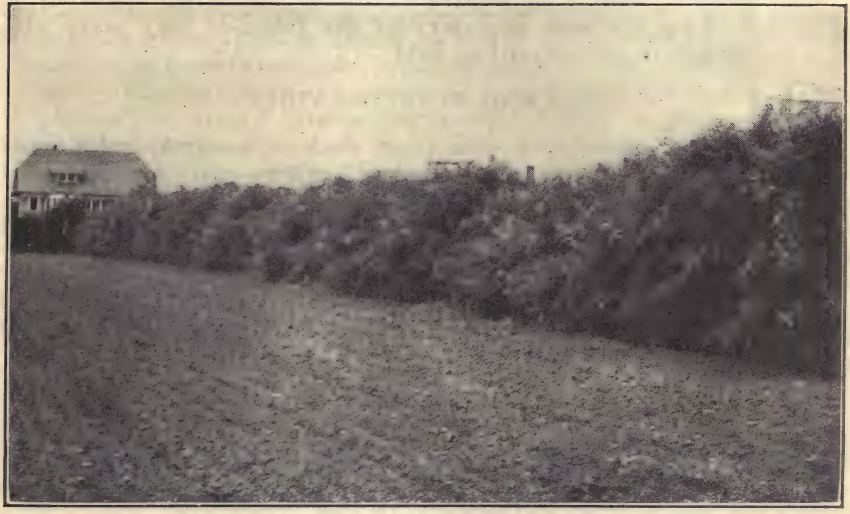

FIG. 17.—Tamarisk hedge 3 years old. Woodward, Woodward County, Okla.

Rough-leaved cornel (*Cornus asperifolia*).
Japanese quince (*Cydonia japonica*).
Chickasaw plum (*Prunus angustifolia*).
Smooth sumac (*Rhus glabra*).
Missouri flowering currant (*Ribes aureum*).
Plum-leaved spirea (*Spiræa prunifolia*).
Coralberry or Indian currant (*Symphoricarpos vulgaris*).
Persian and common lilac (*Syringa persica* and *S. vulgaris*).
Early-flowering tamarix (*Tamarix parviflora*).
Van Houtte's spirea (*Spiræa vanhouttei*).

The tamarix, in addition to having ornamental value as a shrub, is being satisfactorily used as a hedge and windbreak. (Fig. 17.) Many other shrubs have been found hardy for planting on the Great Plains, but the foregoing lists can be depended upon.[3]

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[3] Acknowledgment is due to T. K. Killand, assistant horticulturist of the Northern Great Plains Field Station, Mandan, N. Dak., for the list of shrubs adapted to the northern portion of the Great Plains, and to Christian Jensen, superintendent of grounds and landscape designer of the Oklahoma Agricultural and Mechanical College, Stillwater, Okla., for the list of shrubs for the southern half of the Plains.

LOCATION OF THE PLANTATION.

The shelter belt should be planted on the side of the farm buildings from which the prevailing winds come, which for most of the region means either the northwest or the southwest. It should be long enough to protect the buildings, orchard, and possibly the feed yards, and to be thoroughly effective should be not less than 40 feet wide. It should not be closer than 100 feet to the principal buildings, and it might be well to leave a greater distance, so that there will be ample room for new buildings or for planting more trees. If the trees are planted too close to the buildings, snow is apt to sift through the windbreak and form drifts near buildings. If the windbreak is made up of a belt of hardwoods and then another belt of conifers about 20 feet distant on the sheltered side, the space between them will serve as a snow trap.

The woodlot should be located wherever convenient; but, if it is placed along the west boundary of the farm, it may serve also as a windbreak to an orchard or field.

CHOICE OF PLANTING STOCK.

A plantation established with poor stock is handicapped. Good stock should be chosen. One-year-old or two-year-old hardwood seedlings give best results under normal conditions. Older stock should be avoided. It is more expensive and requires more time and attention to plant. If, however, conifers are planted, nothing smaller than 3-year-old transplants should be used. Transplants are preferred because their more fibrous root systems make them better able to absorb available moisture and accommodate themselves to their new site.

SOURCE OF PLANTING STOCK.

Hardwood seedlings may be purchased or readily grown from seed in the home garden. By collecting seed from trees which occur naturally in the region the planter will be certain of securing seedlings which are true to name and adapted to local conditions.

American elm and silver or soft maple seeds should be sown as soon as they are ripe, which is in May or June. Caragana seeds should be picked in July before they are entirely ripe on account of a habit which the pods have of splitting open when dry and throwing the seeds out. These seeds sprout readily. They may be sown as soon as picked or in the following fall, or they may be stratified and sown the next spring. If the seeds are sown as soon as gathered, the plants will make considerable growth the same summer and will be ready for transplanting to their permanent site at the end of the following summer. Seeds of green ash, boxelder, honey locust, and Russian olive should be collected in the fall, stratified in moist sand over winter, and sown the following spring.

The seeds should be sown in rows, in much the same manner as vegetable seeds. The plants should be watered and cultivated so they will become as large as possible in one growing season. After the middle of August, only enough water should be applied to keep the ground from drying out completely in order to harden the tender wood and thus prevent damage to the plants from early frosts.

Cottonwoods and willows are generally propagated by means of cuttings. These cuttings, which are best made in the fall or early winter, should be from 7 to 10 inches in length and taken from 1-year-old or 2-year-old twigs of healthy trees. Cuttings should always be made with a sharp knife to avoid bruising the bark. If trees free from seed or "bloom" are desired, cuttings should be taken from trees which observation has shown do not produce seed. Cuttings should be buried in cool, moist, well-drained sand until spring. Best results will then be secured by setting them in the garden for a year. Here, where they can be given care, they will take root, and the following spring they may be set out on the permanent site as 1-year rooted cuttings. Unrooted cuttings, however, will often grow if set out directly on well-tilled irrigated land or in subirrigated river bottoms.

Conifers are much more difficult to raise from seed than are hardwoods, and, unless a large project is undertaken, it is inadvisable to attempt to grow them at home. Thrifty stock may be purchased from reliable nurserymen, and sometimes at cost from nurseries maintained by the States. Stock grown as near as possible to the region of planting is always preferable to that grown in more southern districts.

PREPARATION OF SOIL.

Before the planting, the soil must be thoroughly worked up and the sod completely rotted. On new ground it is usually desirable to do the breaking at least two years before planting the trees. During the season following the breaking, the land should be disked, harrowed, or cultivated as often as is necessary to keep the ground clear of weeds, grass, or other vegetation. Clean summer fallow of this type is the best method of preparing land for the planting of trees.

On certain portions of the Plains region where the soil is a sandy loam, the sod not so heavy, and there is danger of the soil's being blown, plowing 12 months previous to planting is sufficient. To prevent winter blowing, such areas should be ridged in the fall by being gone over with an ordinary cultivator or lister.

Better results are usually secured on ground which has been under cultivation for several years. The land should not be cropped to grain, alfalfa, or sweet clover the summer previous to planting, as these crops will use the moisture that should be stored up for the trees.

TIME OF PLANTING.

Throughout the entire Plains region the best results are secured from early spring planting. This gives trees the advantage of an entire growing season in which to become established before they are subjected to the rigors of winter. They also have the advantage of the accumulated winter moisture, and the liability of loss from winter heaving caused by alternate freezing and thawing is slight. Fall planting may sometimes be successful if it is possible to give each tree individual attention, but for general planting it usually results in failure and is not recommended. It is a decided advantage if the planting can be done on damp, cloudy days. Hot, windy days should be avoided for tree-planting operations.

METHODS OF PLANTING.

Planting methods are largely determined by the size of the stock and the condition of the site. Regardless of the method followed, however, certain rules should be observed. When trees are purchased, the package upon arrival should be opened in a barn or shed and the roots well moistened. They should not be exposed to the sun or drying wind. If the roots of each tree are bound with earth and burlap, the burlap need not be removed and the whole bundle should be planted. If the weather permits, the trees should be planted immediately. This insures best results. If that is not possible, they should be "heeled in" in a sheltered location. A trench is dug 8 to 12 inches deep, with one sloping side, against which the trees are placed in thin layers with the roots extending downward. The roots are then well covered with moist soil. Trees may be kept in this way for some time, although warm weather may start their growth. Trees grown at home should not, of course, be dug up until they are to be planted.

In planting, great precautions are necessary to keep the roots of the trees from drying out. They should be kept moist at all times. This is especially important in the case of conifers, for they are easily killed by the exposure and consequent drying out of the roots. On dry, windy days a few minutes' exposure is fatal. The trees may be wrapped in a wet piece of burlap or carried in a bucket, with the roots covered with moist dirt. A method successfully used in a number of places and especially desirable for conifers is that of filling a tank half full of very soft mud and placing the roots of the trees in this. The tank is hauled around on a sled as the trees are planted. The film of mud on the roots keeps them from drying out so rapidly if they should be exposed.

If the soil is not very moist at the time the trees are planted, it is advisable to water them after they are set out wherever that is practicable. This would, of course, be a laborious task on most dry-land farms where water would have to be hauled.

FURROW PLANTING.

A furrow from 8 to 12 inches deep, depending on the length of the roots, should be plowed along a staked line. While the tree is held in an upright position with roots in the bottom of the furrow, the soil should be pulled in from both sides and tamped solidly around the roots, so that the tree will stand upright. The furrow is then filled with soil and leveled. The trees should be set about an inch deeper than they were in the nursery, and the soil should not be hilled up. Not more than one or two furrows should be opened at a time.. If a furrow is left open too long the soil will become dry and the result will be disastrous to the trees.

INDIVIDUAL HOLES.

This method is best adapted for planting trees with large root systems or for use on heavy or rocky soil, although it must again be emphasized that the only certain way of getting results in the Plains region is to plant in thoroughly tilled soil. Steep hillsides which can not be plowed can be planted by this method. A hole should be dug wide enough and deep enough to accommodate the tree roots without crowding. After the tree has been set in the hole with its roots extended, the soil should be pulled in over the roots and tamped thoroughly. Large rocks and sod should not be allowed to fall in around the roots because of the possibility of their causing air spaces, which would allow the roots to dry out. It is best to plant the tree immediately after digging the hole.

SLIT METHOD.

In the slit method a wedge-shaped hole is opened in the ground by inserting a spade and moving it backward and forward. Into this opening the tree roots are inserted full length, and the earth is pressed firmly around them by a thrust of the foot or by making another slit with the spade several inches beyond the tree and pressing the soil toward it. This method is adapted to light, sandy soils where, because of the danger of the soil's drifting, it is unwise to break up all of the sod, and to hillsides where complete plowing might result in erosion. In such sites, furrows may be plowed 6 or 8 feet apart and the trees planted in them. On hillsides the furrows should follow the contours.

NUT PLANTING.

Such trees as oaks and black walnut, which are grown from large nuts, are best propagated by planting the nuts where the trees are to grow, as the long taproots of such trees make successful transplanting from the nursery to the field quite difficult. A good method is to bury walnuts in a shallow pit over winter. When the nuts begin to sprout in the spring they should be planted in shallow holes in well-tilled land and covered lightly.

PLANTING CUTTINGS.

Early in the spring cuttings should be set out in well-tilled soil in a slanting position, with the buds pointing upward, and with about an inch of the cutting protruding above the ground. The cuttings may be set in a furrow or in holes made with a bar or dibble. After they are set, the soil should be pressed firmly about them.

SPACING.

For shelter belts it is desirable to have the trees far enough apart so that they can be cultivated from three to five years, but not so far apart that their value for wind protection will be minimized. Such close spacing as 4 by 4 feet, which has been tried out in certain localities, has not been found practicable in the Plains region in the United States. Trees planted as close as this are difficult to cultivate and are likely to be stunted. It is very doubtful whether the shade provided by closely spaced trees would conserve enough soil moisture to support them during those periods of drought extending over several years to which the region is liable.

As a result of extensive tests in the Plains region, a spacing of 8 by 6 feet or 8 by 8 feet is recommended for shelter-belt planting.

This will permit cultivation both ways for a period of two to five years. It will also provide for sufficient trees so that, if some should die, enough will ordinarily live to make any replanting unnecessary. Some loss is almost certain to occur in every plantation.

Species such as Caragana, buffalo berry, and Russian olive, which are often planted as 1-row or 2-row hedges or windbreaks, should be spaced 2 or 3 feet part in the row.

For woodlots a spacing of 8 by 6 feet is advocated, in order that trees with straight stems and few branches may be produced. If this proves to be too dense in those portions of the Plains having the least rainfall, the smaller trees may be cut out and used for posts or fuel.

On river bottoms or on subirrigated land trees may be spaced closer than on dry land. There a spacing of 6 by 6 feet is recommended for woodlots and 8 by 4 feet for shelter belts.

Some tree planters have advocated planting trees as far apart as 15 by 6 feet or even 24 by 6 feet, because available soil moisture is the controlling factor in tree growth, and ordinarily there is not sufficient moisture on the dry-land farms of the Great Plains to support a denser mature stand. Such wide spacing necessitates clean cultivation for many years, and, as farmers sometimes neglect this on account of the press of other work, their woodlots are soon overgrown with weeds and a heavy loss of trees follows. Many old timber claims, throughout the Plains, with their few struggling, misshapen trees contending against the vegetation, are examples of this. Experience has shown that it is better practice to space the trees more closely, so that cultivation may be discontinued after the fourth or fifth year, when the trees will have shaded out the grass.

CARE OF PLANTATIONS.

CULTIVATION.

A large proportion of failures in plantations is caused by the negligence of the planters. It is a mistake to suppose that trees will live and thrive if they are set out in a weedy or grassy area and then left to shift for themselves. The slow, scrubby growth of natural groves of trees in the Great Plains and the miserable appearance of neglected planted areas are excellent illustrations of the truth of this. Cultivation is just as necessary in establishing a successful plantation of trees as in other lines of agriculture, and the results are proportionate to the amount of labor expended in keeping the soil loose and free from weeds. Cultivation stimulates tree growth, and no other operation helps so much to lessen the losses caused by insufficient moisture.

The area should first be cultivated at least one year and preferably two years before the trees are planted. After planting, cultivation should be repeated as often as necessary to keep the weeds down and should be continued every season until the trees have grown too large for the work to be done between the rows. Cultivation should extend 5 or 10 feet beyond the limits of the plantation. This strip of cultivated soil will retard the encroachment of grass and weeds and also serve as a firebreak. Under no circumstances should the weeds be allowed to grow so high that a plow must be used to destroy them; weeds rob the trees of moisture, and a plow or any deep cultivator may injure the fine tree roots. A one-horse cultivator can be used to best advantage if the trees are spaced as recommended.

The only other method that seems practicable in eliminating weeds from small plantings is to fence the area after the third or fourth season and use it for a chicken yard. The chickens will keep down the weeds and insects and scratch up the soil.

THINNING.

The object of thinning is to remove those trees which, because either of their unhealthy condition or crowded position, are retarding the growth of the more desirable individuals. Just as an overcrowded stand of vegetables is thinned by a gardener, so the poor trees in a woodlot should be cut out. The result is the best development of those remaining. The best-formed, most valuable, and most healthy trees should be selected to remain. Need of thinning is indicated if, on account of crowding, there are many dead or dying trees in the stand, or if the trees are very slender in proportion to their height.

Although thinnings will not ordinarily be necessary until the wood lot is 15 to 20 years old, on irrigated land they may be desirable earlier. Care should be exercised not to remove so much material that the sun will shine through and induce a growth of grass under the remaining trees. The openings in the tops should close in three or four years. The fact should not be overlooked that in a large grove the shade afforded by the crowns of the trees takes the place of cultivation in keeping the grass down and lessening the evaporation of water from the soil. The first thinning will yield fuel and small posts, and, if the poorer material is removed each time, each subsequent thinning will remove bigger and better material.

A shelter belt should ordinarily be thinned only if many of the trees are plainly in an unhealthy condition. Unless considerable care is exercised, the removal of trees from a shelter belt will lessen its protective value.

PRUNING.

Pruning of the branches of trees in a plantation is in general unnecessary and, because of the cost of labor involved, undesirble. Pruning in shelter belts is not at all advisable, as a dense growth not only gives the most protection to the farm buildings but also protects the trees themselves. The bushy growth protects the trunks of the trees from sun scald, prevents the growth of grass and weeds, and retards evaporation. Species like the Siberian pea tree, which do not develop a main stem but send out a dozen or more shoots, should not be pruned. In the Plains region the greatest value of conifers is in the protection which they afford against wind. As low branches make them more effective in this respect, they should ordinarily not be pruned.

If a young tree is frozen to the ground for a few years in succession it will send out a number of shoots from the base and make little growth in height. To stimulate growth, all of these shoots except one should be cut off close to the base. This shoot should be allowed to become the leader, and, if shelter is the purpose of the planting, none of the branches it sends out should be pruned.

In woodlot plantations where it is desired to produce a good grade of material, it may sometimes be profitable to prune the best trees by cutting off such dead and brittle limbs as can be reached. Dead branches which persist on some hardwoods are likely to form loose knots and should be removed. If, because of wide spacing, the trees are assuming a poor timber form, it may be necessary to correct this condition by pruning.

Pruning may be done at any season, but fall or winter, when the tree is dormant, is the preferable time. It should not be overdone. If a tree is pruned too far up, it may become top-heavy and be easily broken off by a severe wind. Sharp tools should be used. Branches should be cut off close to the main trunk so that no stubs are left through which wood-rotting fungi may enter the tree.

PROTECTION.

AGAINST CATTLE AND RODENTS.

Grazing animals should never be allowed to use the plantation as a pasture. The animals almost invariably cause damage to the trees by nipping off the branches, peeling the bark, trampling the small trees, and packing the ground hard and dry, thus robbing the trees of much-needed moisture. Every plantation should be fenced with rabbit-proof woven-wire fence to keep out live stock and rabbits.

The jack rabbit is the worst animal pest with which the grower of trees in this region has to contend. It not only strips the bark from the older trees, but will also cut off seedlings at the ground or at snow line. It especially prefers elm and ash, but will cut off poplar, willow, and young jack pine branches when they extend above the snow. Rabbits like alfalfa better than trees, and, if a stack of alfalfa is near by, they will seldom bother the trees.

Rabbits may be poisoned by sprinkling a strychnine solution on alfalfa leaves. This is prepared by dissolving one ounce of strychnine sulphate in 2 gallons of hot water and sprinkling it over 10 pounds of alfalfa hay leaves. The leaves should be mixed thoroughly until all moisture is absorbed. Other methods of poisoning may be learned from the Bureau of Biological Survey, Washington, D. C., from State foresters, or from experiment stations listed on page 34 of this bulletin.

Rabbits may be trapped readily by the following method, which has been suggested by the Kansas State Agricultural College Experiment Station in its Circular No. 17:

> Sink a barrel or keg in the ground level with the surface. Fit the head slightly smaller than the top and allow it to swing freely on a rod or old broomstick. Pieces of apple or corn may be fastened on the outer edge of the cover, and when the rabbit attempts to get these, the lid slips in and he slides into the barrel, while the lid, which is slightly heavier on one side than the other, assumes its original position. The heavier side should rest against a heavy nail or bolt so that only the lighter side of the lid will drop. The whole thing should be covered over with brush.

In many parts of the Great Plains, pocket gophers cut off the roots of young trees. These rodents may be poisoned by sprinkling a mixture of strychnine and saccharine upon cubes of sweet potatoes or carrots, which are then inserted into the underground runways. Trapping is the surest method of exterminating pocket gophers, and several good traps for this purpose are on the market.

AGAINST INSECTS.

Various species of trees are attacked by insects in different parts of the Plains region. Poplar beetles and their black larvæ eat willow and poplar leaves. These beetles suggest the Colorado potato beetle in shape, but they are somewhat smaller and are black in color tinged with blue and more or less striped or spotted with yellow or orange. They appear when the leaves begin to come out in the spring and are at their worst during the month of June. Four to five broods may be produced before fall. Their attack is followed by disastrous results to the foliage and later by the death of the trees. Spraying with lead arsenate, prepared as directed on the containers, will destroy the insects. The spraying will yield most satisfactory results when the leaves are about half grown. The reappearance of the beetles in great numbers may necessitate a repetition of the treatment during the season.

The large, green, wormlike larvæ of certain moths are very destructive to the foliage of poplars and boxelders. One large worm may eat all the leaves on a young tree in a short time. A thorough spraying with lead arsenate should control this pest. Hand picking is also often resorted to.

Blister beetles are found on the young shoots of the Caragana in the month of June. They are of three kinds, the gray and the black (about three-fourths of an inch to 1 inch long), and the metallic blue (1 to 2 inches long). Spraying with lead arsenates does not seem to kill them, but drives them to other plants. They do, however, eat leaves sprayed with Paris green and are killed. The Paris green, however, does not adhere so well to the leaves and is generally more expensive. The Caragana does not seem to suffer much from these beetles unless entirely denuded. This denuding frequently weakens the trees to such an extent that they die within a year or so or leads to further and more severe attack each following year until death results. When only the ends of the young growth are eaten, the trees will often put out new leaves later in the summer. Blister beetles also attack green ash, Russian olive, and hackberry, sometimes doing considerable injury to young plantations.

The pine-tip moth (*Evetria bushnelli*) causes some damage to pine trees planted in western Nebraska by boring into the young shoots and hollowing them out for a distance of several inches. This distorts the growth of the tree if the leader is attacked several years in succession. There is no practical remedy for the control of this pest.

Black locust is well adapted to the southern part of the Plains, but its planting can hardly be generally recommended because of the damage done by the locust borer. Success has been attained in planting black locust in the low, wet bottom lands of rivers in western Texas and Oklahoma. The absence of the borers here has been ascribed to planting the trees so densely that the trunks are shaded. The shade, together with the rapid growth on the bottoms, seems to make the locust almost safe from attack. Green ash has also been severely injured in portions of the Plains by a borer, but in most places this insect appears to be held in check by nature. The cottonwood borer causes some damage, but for the most part it is controlled by natural enemies.

Insects may cause serious damage. If an insect attack is severe, aid should be sought from the Bureau of Entomology, Department of Agriculture, Washington, D. C., or from the State experiment stations.

AGAINST FIRES.

In places where there are few cultivated farms and there is danger from prairie fires, a fire line 5 to 10 feet wide should be plowed around the plantation. If it is placed next to the outer rows of trees and kept clean, the growth of the exterior trees will be greatly stimulated. In sections where there is danger of the soil's being blown, the fire line should not be placed adjacent to the trees; for, if the soil is blown, small trees may be buried or the roots of larger ones may be uncovered.

WINTER INJURY.

Trees are more or less subject to winter injury throughout the Plains region. The causes of this are briefly as follows:

Trees that are not hardy to the section wherein they are planted are subject to freezing in the fall and winter. This is generally due to the inability of the plant to stand the severe winter, or to failure to ripen the year's growth of wood in the fall because of the shorter growing season of the region.

Other trees are subject to sun scald on the trunks and branches during winter and early spring. This causes the tissue on the south side to die and leaves a scar that forms a ready entrance for diseases.

Even hardy trees often dry out in the winter or spring during prolonged periods of drought. These usually recover and resume their natural growth unless killed to the ground.

Trees are often tender the first few years after planting, but later become acclimated and are thereafter hardy.

RESULTS.

There are very few plantations more than 15 years old in the Great Plains, in the development of which the principles of good tree planting, such as the proper selection of species and careful methods of planting and cultivation, have been followed. Hence there are few available figures showing the growth and the products that may be obtained. A large number of tree claims were established between 1878 and 1891 under the timber-culture act; but some of these plantations have been damaged by prairie fires, some have been ravaged by insects, some have been cut out or have died out, and on the whole they have been sadly neglected. (Fig. 18.)

Such data as are available indicate that despite scant rainfall, drying winds, and extremes of heat and cold, valuable wood products can be obtained from planting in the Plains region. Some of the hardiest species are either of poor quality or of poor form for posts or other timber products. Their value lies in their ability to grow at all or in their low-branching, compact habit, which is so necessary for making shelter and which is of more importance in the Great

Plains region than the production of clear timbers. It is well to remember, however, that even nondurable fence-post woods, which the farmer situated long distances from the railroad may be forced to use, may be given an average life of 20 years by treating them with creosote.[4]

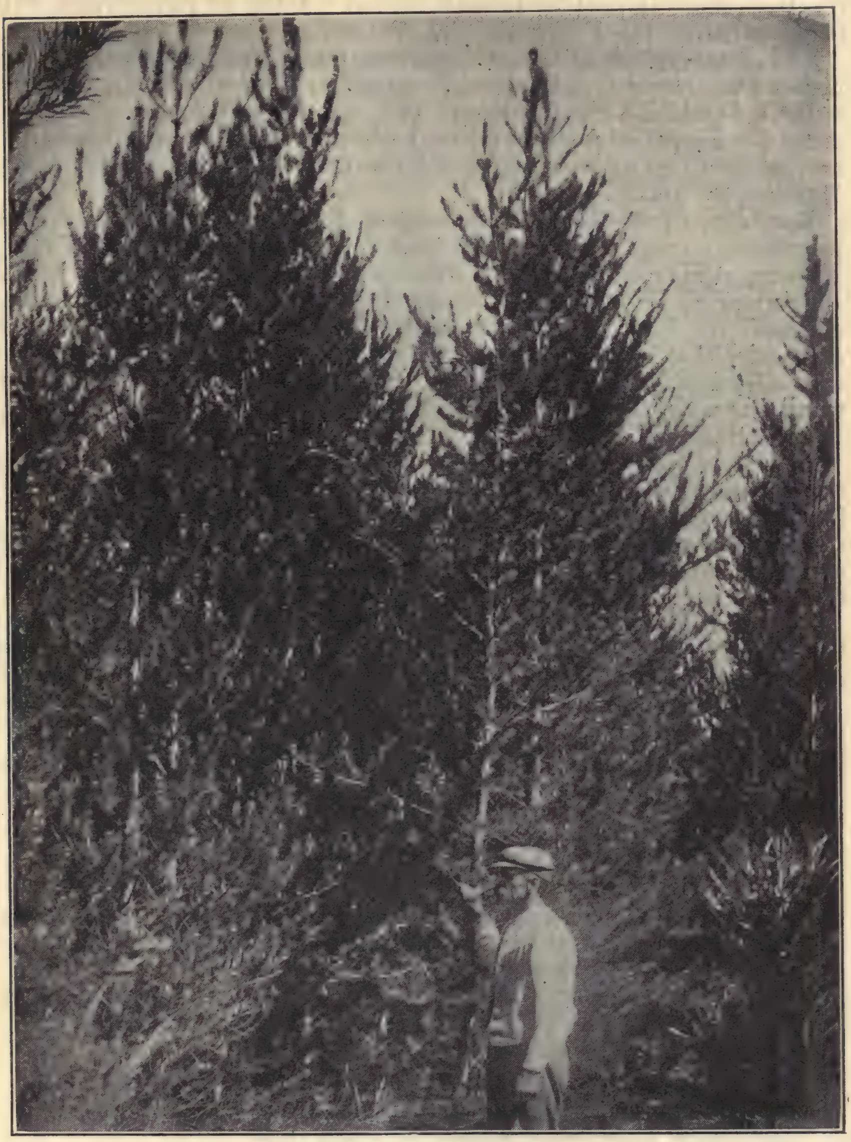

FIG. 18.—Jack pine plantation 14 years old. Height 12 to 24 feet. Holt County, Nebr.

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[4] See U. S. Department of Agriculture Farmers' Bulletin No. 744, "The Preservative Treatment of Farm Timbers."

SOURCES OF INFORMATION AND PLANTING STOCK.

Private nurserymen are usually able to supply planting stock of the trees more important in each region. A list of nurserymen will be supplied by the Forest Service, Washington, D. C., upon request.

The Northern Great Plains Field Station at Mandan, N. Dak., furnishes some forest-tree stock to dry-land farmers only in the western half of North and South Dakota and in eastern Montana and Wyoming for cooperative experimental plantings. Further information may be obtained by writing the Northern Great Plains Field Station, Mandan, N. Dak.

Residents of the sixth congressional district in western Nebraska may receive trees free, so far as they can be spared, from the Bessey Nursery at Halsey, Nebr. Applications should be made to the forest supervisor at Halsey before March 1 of the year in which the trees are desired. Each applicant usually is given not to exceed 200 trees of species that have been found adapted to this region, as the intent of the legislation authorizing this distribution is to interest people in tree planting rather than to furnish large numbers of trees for woodlot planting.

The State forester of Colorado sells trees at the cost of production to residents of that State. Particular attention is being paid to raising trees adapted to the treeless eastern half of the State. Information regarding the distribution and price lists may be secured upon application to the State forester, Colorado Agricultural College, Fort Collins, Colo.

Trees are sold to residents of Kansas by the Fort Hays Experiment Station, Hays, Kans. A catalogue and price list of trees will be mailed upon application to the station.

In the Great Plains region, persons who wish more specific information should apply to one or more of the following sources:

NORTH DAKOTA.—Northern Great Plains Field Station, Mandan, N. Dak.
  North Dakota Agricultural College, Agricultural College, N. Dak.
SOUTH DAKOTA.—Northern Great Plains Field Station, Mandan, N. Dak.
  State College of Agriculture, Brookings, S. Dak.
MONTANA.—Northern Great Plains Field Station, Mandan, N. Dak.
  State College of Agriculture, Bozeman, Mont.
  State forester, Missoula, Mont.
  District forester, Forest Service, Missoula, Mont.
WYOMING.—Northern Great Plains Field Station, Mandan, N. Dak.
  College of Agriculture, Univ. of Wyoming, Laramie, Wyo.
NEBRASKA.—Forest supervisor, Halsey, Nebr.
  State forester, Department of Conservation and Soil Surveys, Lincoln, Nebr.
COLORADO.—State forester, Fort Collins, Colo.
  District forester, Forest Service, Denver, Colo.
KANSAS.—Fort Hays Experiment Station, Hays, Kans.
  State forester, Manhattan, Kans.
OKLAHOMA.—Woodward Field Station, Woodward, Okla.
  Agricultural Experiment Station, Stillwater, Okla.
  Lawton Field Station, Lawton, Okla.
NEW MEXICO.—College of Agriculture, State College, N. Mex.
  Tucumcari Field Station, Tucumcari, N. Mex.
  District forester, Forest Service, Albuquerque, N. Mex.
TEXAS.—State forester, College Station, Tex.

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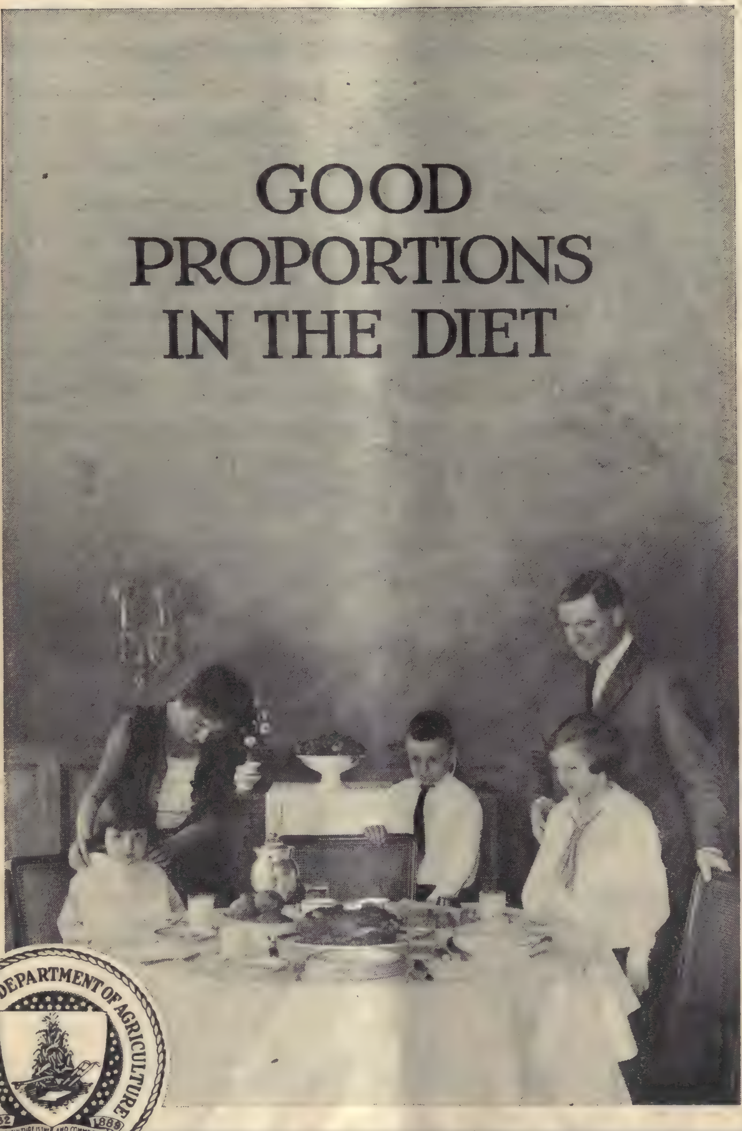
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1313

GOOD PROPORTIONS IN THE DIET



HOUSEKEEPERS often feel the need of some simple plan by which the foods used in their families can be compared in kind and quantity with those really needed. The kinds of foods needed and, in a general way, the proportions in which these foods should be used can easily be stated. But since families differ greatly in size and in the ages and occupations of their members it is very difficult to state the amounts needed in such a way as to be universally helpful. In this bulletin proportions are discussed in terms of the amount of food needed by a family consisting of a father and a mother, both doing active but not hard muscular work, and three children under 12 years of age. Such a group of people is what has come to be known as the "average," or "census," family and is here taken as the starting point for considering the needs of other families, smaller as well as larger, and engaged in more active and less active work.

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GOOD PROPORTIONS IN THE DIET.

CAROLINE L. HUNT, *Specialist, Office of Home Economics, States Relations Service.*

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KINDS OF FOODS NEEDED.

THE NUMBER of different food materials available in most parts of the United States is very great and is constantly increasing as a result of improved methods of agriculture, the invention of new manufacturing processes, the introduction of foreign food plants, and the cultivation of wild varieties. There is no one of all these many foods that can not be introduced into the diet in such a way as to contribute to its wholesomeness or its attractiveness, but the number of different kinds of food needed is very small. Many food materials, the various cereals, for example, are practically interchangeable in the diet. In fact, most of the common foods may, as suggested in other publications of this department,[1] be classified into five groups according to their composition and uses, namely, (1) vegetables and fruits, (2) meat, milk, and other foods depended on for complete, or efficient, protein, (3) cereals, (4) sugar and sugary foods, and (5) fats and fat foods.

A meal, a day's ration, or a weekly food supply made up from representatives of all these five groups is likely to provide all the substances required to make the diet wholesome and attractive, and for this reason the classification should serve as a guide in the selection of foods and the planning of meals. It should be of some help, too, in comparing the cost of different foods, for it separates foods that have little or nothing in common, and brings together under one head food materials that are enough alike to be compared in price. For example, to know that a pound of salt codfish costs 10 cents more than a pound of prunes does not make economical meal planning easier. It is helpful, however, to know that one kind of breakfast cereal costs 15 cents, while another that might be substituted for it costs 7 cents, or that a certain amount spent for an inexpensive kind of fruit will bring as good returns in food value as twice that amount spent for some out-of-season variety.

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[1] Farmers' Buls. 717, Food for Young Children; 808, How to Select Foods: I. What the Body Needs; 817, How to Select Foods: II. Cereal Foods; 824, How to Select Foods: III. Foods Rich in Protein; and U. S. Dept. Agr. Bul. 975, Food Values: How Foods Meet Body Needs.

Sample or suggestive weekly food supplies of the five different groups of foods mentioned in the preceding paragraph are shown in Figures 1 to 5. These pictures are taken from a set of eight charts prepared by the Office of Home Economics to show the principles of food selection. The information on the three remaining charts, which is chiefly descriptive and explanatory, is included in the discussions which follow, but it has been expanded by the addition of certain details which for lack of space were omitted from the charts.

The uses of the different kinds of foods are briefly outlined in what follows.

GROUP I. VEGETABLES AND FRUITS.

Vegetables and fruits are depended on for flavor, bulk, mineral substances, particularly iron, and for vitamins, of which at least three kinds, called A, B, and C, are now considered necessary. Spinach stands out among the other foods of this group because of its exceptionally large percentage of iron. The green-leaf vegetables as a class, including lettuce, spinach, kale, dandelion greens, the green tops of turnips, or of beets, or of radishes, and many other vegetables commonly used for salads and greens are especially useful in supplying vitamin A, which is now believed to be necessary for normal growth and for the continued bodily well-being even of adults. Practically all the vegetables and fruits furnish vitamin B, which is, however, so widely distributed among natural food materials that it presents less of a problem to the housekeeper than either of the others. The two chief sources of it are the vegetables and fruits and the so-called whole-grain cereals. Many fruits have been found to supply vitamin C. Lemons, oranges, and tomatoes are considered especially rich in it, and some of the vegetables, notably cabbage and some varieties of turnips, contain comparatively large amounts. White potatoes are also considered an important source of this vitamin in the diet, not because they supply more, pound for pound, than many other foods, but because being mild in flavor and comparatively cheap they are used in larger amounts in most families than any other one vegetable.

It is now believed that the vitamins are to some extent destroyed by drying and also by cooking, particularly in the presence of soda. Probably no two foods are affected to the same extent, and even if the effect on every food were known, the facts would be difficult to keep in mind. In the absence of definite available knowledge on this subject it is wise for the housekeeper to use regularly some uncooked fruits or tomatoes, fresh or canned, and some green-leaf vegetables. The last mentioned should be used either raw or cooked only enough to make them taste good and without unnecessary loss of their juices. Canned and dried vegetables and fruits may all be used for the sake of economy or convenience or to give bulk to the diet, but never to the exclusion of green-leaf vegetables and fresh fruits. There is no way at present of measuring the exact amount of fruit juices needed for health. It seems probable, however, that it is not large, and the housekeeper who can not afford to serve whole oranges, grapefruit, or fresh tomatoes is probably on the safe side, if she makes a practice of introducing small amounts of orange or lemon juice or canned tomatoes into her bills of fare. An orange cut up with other fruits or a little lemon juice added to sliced bananas, stewed prunes, or other fresh or dried fruits is helpful. There are many desserts and beverages, too, in which small amounts of orange or lemon juice can be used, and many gravies, sauces, and soups that are improved by a little tomato juice. Regularity of supply is probably more important than the use of large amounts.

GROUP II. FOODS DEPENDED ON FOR EFFICIENT PROTEIN.[2]

Representative of the foods that furnish efficient protein are flesh foods, including lean and medium fat meats, poultry, game, fish, and sea foods; eggs; milk; cheese of various kinds; peanuts and soy beans. These foods, though differing much in other respects, are alike in furnishing a kind of protein that will serve to build the protein found in the tissues of the body. Such foods as bacon, salt pork, fat pork sausage, and cream furnish the same kind of protein as the foods of this group, but are too fat to be used as the means of supplying any considerable portion of the needed amount. As a rule, if a food contains two and a half times as much fat as protein, it is listed among the foods of Group V, which are depended on to give richness to the diet rather than to furnish protein.

Some of these foods have special uses. Milk and cheese are very rich in lime, and meat and eggs in iron. Milk from properly fed cows and egg yolks are important sources of vitamin A. In spite of their differences, these foods may be considered interchangeable in the diet of the adult, but in the diet of children none of the ordinary foods can take the place of milk.

GROUP III. CEREAL GRAINS AND THEIR PRODUCTS.[3]

The cereal-grain foods are flour, meal, breakfast foods, bread, rolls, crackers, and all other foods that are made wholly or chiefly from the cereal grains such as wheat, corn, rye, rice, barley, and oats. These cereal foods are depended on to supply protein, starch, and, particularly if they are made from the whole grain, mineral substances and vitamins. Vitamin B is found so near the germ that it is likely to be lost if the germ is removed. The mineral substances are found chiefly in the germ and in the outer coatings of the grain. It is generally agreed that cereal foods keep better if the germ has been removed, and many people prefer white to whole-wheat flour because it makes lighter bread. However, if white bread only is served, care should be taken either to introduce whole-grain cereals into the diet as breakfast foods or in some other way, or to provide an unusually large proportion of vegetables and fruits. (See p. 2.)

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[2] Farmers' Bul. 824, How to Select Foods: III. Foods Rich in Protein.
[3] Farmers' Bul. 817, How to Select Foods: II. Cereal Foods.

GROUP IV. SUGAR AND SUGAR FOODS.

The sugar foods are sugars of different kinds, including granulated, pulverized, lump, brown, and maple; molasses; honey; sirups; candy; sweet chocolate; rich preserves; jellies; jams and marmalades. These foods can be depended on for fuel and flavor, but not for protein, vitamins, and mineral substances. They are therefore not so essential as the other groups. It should be said, however, that sugar at ordinary prices is an economical body fuel and a very economical flavoring material as compared with most extracts and even with spices. If sweets are used in proper proportions to other food materials and are not served in such a way as to destroy the appetite for other foods, they play an important part in the diet.

GROUP V. FATS AND FAT FOODS.

Fats and fat foods include butter, oil, lard, suet, and other table and cooking fats; cream; bacon; salt pork; pork sausage; chocolate; and rich or oily nuts. Most of these foods are prepared by separating fat from natural food materials such as meat, milk, olives, corn, and cotton seed. The advantage of using them in this separated form is that in this way the richness and flavor that they give to the diet are more easily distributed through the other foods. Some of the fat foods, especially butter and cream, furnish vitamin A and for this reason have great advantage over the other foods of the group, particularly when milk, eggs, and green-leaf vegetables can not be obtained in sufficient amounts.

PROPORTIONS OF FOODS NEEDED.

All of the foods mentioned in the preceding paragraphs, and in fact all foods, furnish body fuel or material that can be burned in the body to give it energy and incidentally to keep up its temperature. The fuel supplied by Group I, the vegetables and fruits, is chiefly sugar and starch; that supplied by Group II, namely, milk, meat, eggs, and cheese, chiefly complete, or efficient, protein and fat; that supplied by Group III, the cereals, chiefly protein and starch, the latter being usually six or seven times as much by weight as the former; that supplied by Group IV, the sweets, almost exclusively sugar; and that supplied by Group V, almost exclusively fat. As a rule, the diet will be sufficiently bulky and flavorful and will furnish the right proportions of starch, fat, and sugar for the taste of most people if the vegetables and fruits furnish about 20 per cent of the fuel; the meat, eggs, milk, and similar foods, 25 per cent; the cereal foods, 25 per cent; sweets, 10 per cent; and fats and fat foods, 20 per cent. It will also furnish satisfactory kinds and amounts of protein, mineral substances, and vitamins. These proportions have, therefore, been adopted in making up the sample food supply shown on pages 6 to 14.

The choice of the particular foods from each group to be here illustrated was determined by the facts stated in the paragraphs on the special values of the foods of different groups (pp. 2–4). Many other combinations, more meat and fewer eggs, for example, or more butter and less bacon, or more oatmeal and less flour, would be equally good.

The proportions given in the preceding paragraph are especially adapted for persons who do about an average amount of muscular work. Those who do light muscular work or lead sedentary lives would naturally eat a larger proportion of vegetables, fruits, and efficient-protein foods, and a smaller proportion of cereals, fats, and sweets. On the other hand, those who do hard muscular work seem to need a larger percentage of energy-yielding foods, such as cereals, fats, fat meats, and sweets.

AMOUNTS OF FOODS NEEDED.

It is far easier to state the kinds of foods which together make a satisfactory diet than it is to state the amounts of food needed by an individual or a family. Individuals differ greatly, of course, in age, size, and occupation, and families also differ widely, one from another. It is out of the question, of course, to consider in detail the needs of all families separately and so it has become customary to use a type family for discussion. The family usually chosen for this purpose consists of a man and a woman, both doing moderately active muscular work, and three children, under 12 years of age. Boys and girls over 12 are believed to need as much food as adults. The children in this "average," or "census," family are thought of as having combined ages of not more than 24 years. Such a family serves as the unit in most discussions of food needs and costs of living. The foods shown (Figs. 1 to 5) make a good weekly supply for this unit family.

Such a family needs about 80,000 calories of energy per week, or to use a term which seems more appropriate in speaking of food, 800 one-hundred calorie portions or servings. The food required by this family is about the same in amount, though not necessarily in kind, as that needed by two men and two women all doing light muscular work, or by two men and one woman doing hard muscular work, like that of a farmer and a farm housekeeper. A farm household in which there were two men and one woman all doing hard muscular work, a girl and a boy in their teens, and one younger child would need about twice as much food. Throughout this bulletin the term "adult" should be understood to include boys and girls over 12 years of age, and the term "work" to include also running, jumping, and other activities ordinarily called play.

When the food supply illustrated (Figs. 1 to 5) is used as a guide in the selection of food for a family with children, the first list of efficient-protein foods (p. 8) should be used. When, on the other hand, it is used as a guide to the selection of foods for families of adults only, the second list of efficient-protein foods (p. 9) which contains less milk and more meat, may be used.

TWO WAYS OF STATING AMOUNTS NEEDED.

The amounts of foods needed for a given person or family are usually stated in one of two ways, (1) in terms of such familiar units as pounds, bushels, and dozens; or (2) in terms of units by which energy or the power to do work is measured, that is, in calories and hundred-calorie portions. Rules for estimating the amount of food needed in terms of calories and hundred-calorie portions are easy to make but troublesome to follow, for foods are not at present bought or sold by calories or hundred-calorie portions, nor are these units used in recipes. On the other hand, exact rules expressed in terms of pounds, dozens, and other familiar units are very difficult to make. The chief reason for this is that food materials differ greatly, not only in the kinds of nutrients they contain, but also in the amount of water and of inedible material such as bone and shell. Even those foods that serve practically the same purpose in the diet are not interchangeable pound for pound. For example, a pound of sugar provides 16 ounces of sugar; a pound of honey, about 12 ounces of sugar; and other sweet foods in common use differ even more. It goes without saying that if a family uses candy, sirup, molasses, honey, and rich preserves purchased as such, it can not safely use so much sugar as it would otherwise; but it is quite impossible to state the total number of pounds of sweets that can be safely used without knowing which ones are to be selected and in what proportions they are to be used.

For these reasons, the amounts of the various kinds of foods that are necessary or desirable are stated in two ways in this bulletin, by weight and by hundred-calorie portions. This is done in the belief that estimates in pounds, dozens, and quarts may be more useful to some housekeepers and that estimates in hundred-calorie portions may, because of their greater definiteness, be more useful to others.

In most cases, the suggested allowances of food from the different groups are given, first in terms of some familiar member of the group; after that suggestions are made for the substitution of other foods that serve about the same purpose. For illustration, allowances of cereal foods are given, first in terms of pounds of dry cereal foods, which, of course, include the flour used in making bread. Many people, however, buy bread instead of having it prepared at home, and an allowance must be made for the nutrients which such bread contains. For this reason the statement is made that a pound of bread usually contains the equivalent of about three-fourths pound of flour and therefore counts as about three-fourths pound of dry cereal in making up the total allowance.

A WEEK'S SUPPLY OF VEGETABLES AND FRUITS FOR THE AVERAGE, OR CENSUS, FAMILY.

The sample weekly supply of vegetables and fruits (Fig. 1) for an average, or census, family represents about 70 pounds fresh weight, or about 160 hundred-calorie portions. It is believed that this amount, if regularly used, will insure the required bulk and mineral substances, even though some of the vegetables and fruits are canned and some dried; and that it will also furnish the required vitamins, provided green-leaf vegetables and fresh fruits are regularly included in small amounts. The separate items in the sample supply are as follows:

	Pounds.
Fresh vegetables and fruits:	
Potatoes, white, ½ peck	7
Potatoes, sweet, ½ peck	7
Asparagus	2
Beets, with greens	2
Carrots	2
Cabbage	2
Squash	2
Turnips	2
Celery	1
Lettuce	1
Onions	2
Tomatoes, 4 medium-sized	1
Rhubarb	1
Bananas, 1 dozen medium-sized	3
Oranges, ½ dozen medium-sized	3
Apples, 8 medium-sized	3
Fresh vegetable and fruits—Con.	
Pineapple (1)	2
Strawberries, 1 quart	1
Total	44
Canned vegetables and fruits:	
Peas, 1 quart	2
String beans, 1 quart	2
Cherries, 1 quart	2
Peaches, 1 quart	2
Total	8
Dried vegetables and fruits:	
Lima beans	2
Raisins	1
Total	3

HOW TO ESTIMATE THE NUMBER OF POUNDS FRESH WEIGHT.

When all the vegetables and fruits used are fresh it is easy to estimate the weight, but when some are dried and some are canned it may be difficult. Vegetables and fruits lose on the average about five-sixths of their weight when they are dried, the loss being partly due to the removal of inedible portions, but chiefly to the passing off of water. A given number of pounds, dried, therefore, is likely to furnish as much fuel and mineral substances as six times that number of pounds fresh. A given number of pounds of canned vegetables and fruits, on the other hand, seldom corresponds in fuel and mineral substances to more than the same number of pounds fresh or as purchased, i. e., before skins, seeds, pods, outer leaves, and other inedible portions have been removed.

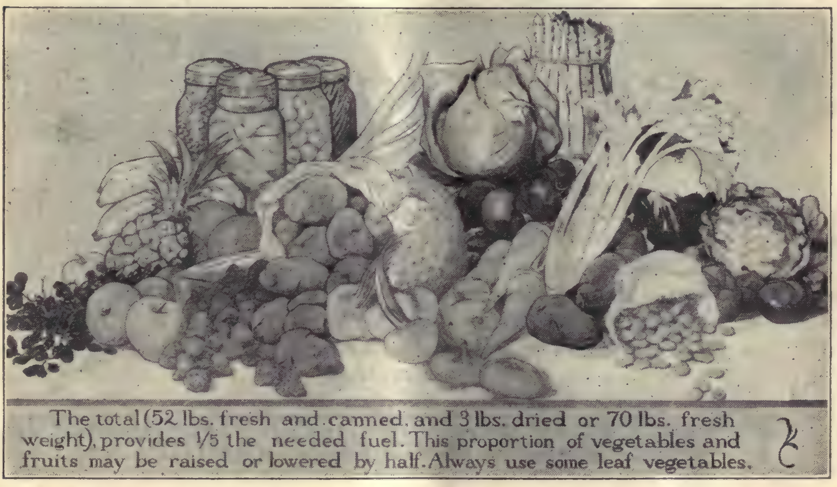

The total (52 lbs. fresh and canned, and 3 lbs. dried or 70 lbs. fresh weight), provides 1/5 the needed fuel. This proportion of vegetables and fruits may be raised or lowered by half. Always use some leaf vegetables.

FIG. 1.—Chart showing vegetables and fruits, fresh, canned, and dried, which together supply about 160 hundred-calorie portions. Any other combination of ordinary vegetables and fruits equivalent to 70 pounds of fresh material would supply about the same amount of body fuel.

In making up the sample supply of vegetables and fruits, it was estimated that the 8 pounds of canned peas, string beans, cherries, and peaches correspond roughly with 8 pounds of these same foods fresh, and that the 3 pounds of dried lima beans and raisins correspond roughly with 18 pounds of fresh lima beans and grapes. The 44 pounds of fresh vegetables and fruits, the 8 pounds canned, and the 3 pounds dried, together represent, roughly, 70 pounds fresh weight.

This method of estimating the original or fresh weight of the vegetables and fruits used in the course of a week is recommended to the housekeeper who wishes to keep her food supply up to the standard. Dried and canned vegetables and fruits can never wholly take the place of fresh vegetables and fruits; but if only a small part of the 70 pounds can be obtained in fresh form, it is better to make up the remainder in the form of dried and canned products than to reduce the total.

HOW TO ESTIMATE THE ENERGY VALUE OF THE VEGETABLES AND FRUITS.

The fuel or energy values per pound of the different vegetables and fruits differ considerably, but from dietary studies made in the Office of Home Economics it has been found that the fresh and canned vegetables and fruits in the variety in which they are used in most families seldom represent less than 225 calories, or 2¼ hundred-calorie portions per pound, and that the dry vegetables and fruits seldom represent less than 1,350 calories, or 13½ hundred-calorie portions per pound.

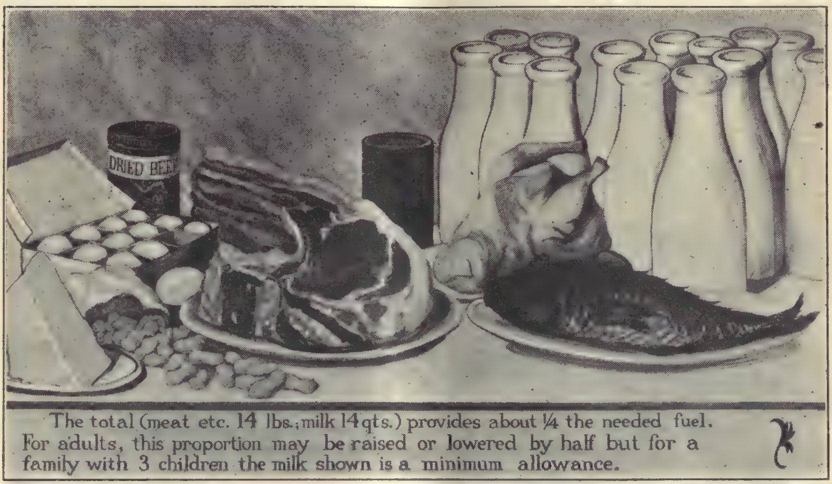
According to these figures the fresh and canned vegetables and fruits in the sample weekly supply should furnish at least 117 hundred-calorie portions and the dried at least 40½ hundred-calorie portions, making a total of 157½ hundred-calorie portions for the group, or about 20 per cent of the total 800 hundred-calorie portions needed. In this way the amount of fuel furnished by the vegetables and fruits in any food supply and the proportion of this fuel to the total fuel needed can be quickly estimated.

A WEEK'S SUPPLY OF EFFICIENT-PROTEIN FOODS FOR THE AVERAGE, OR CENSUS, FAMILY.

A sample weekly food supply of meat, eggs, milk, and other foods depended on for efficient protein, such as would be needed by the typical family, is shown in Figure 2. The supply includes 14 quarts of milk and 14 pounds of flesh foods, cheese, eggs, and peanuts, or about 200 hundred-calorie portions. It is believed that if this amount of food of this group is used, the proportion of efficient protein in the diet will be about right. The separate items are as follows:

	Quarts.
Milk	14
	Pounds.
Beef, fresh	4
Beef, dried	1
Fowl	3
Fish, fresh, lean	2
	Pounds.
Fish, canned	1
Cheese	1
Eggs, 1 dozen	1½
Peanuts, 1 quart	½
Total	14

Children need more milk than adults, and the number of quarts that should be used depends on the family. The 14 quarts shown in Figure 2 is believed to be as little as is wise for a family of two adults and three children. For this family 3 quarts a day, or 21 quarts a week, would be a better allowance, and would furnish daily three glasses for each child and a small quantity for general use. Since the added quart of milk would be chiefly for children, it would hardly be practicable to reduce the other foods much. A family of adults would probably use less milk in proportion to meat, cheese, and eggs. For three adults doing hard work or four doing light work (see p. 5) 1 quart of milk and 2½ to 3 pounds of the other foods would be a more usual daily allowance. For either of these two families the following may be used as a guide to the amount of efficient-protein foods used weekly:



The total (meat etc. 14 lbs.; milk 14 qts.) provides about ¼ the needed fuel. For adults, this proportion may be raised or lowered by half but for a family with 3 children the milk shown is a minimum allowance.

FIG. 2.—Chart showing efficient-protein foods which together supply 200 hundred-caloric portions. Any other combination, consisting of 14 quarts of milk and 14 pounds of flesh foods, cheese, and eggs, would furnish about the same amount of body fuel.

	Quarts.		Pounds.
Milk	7	Meat or fish, dried	1
	Pounds.	Meat or fish, canned	1
		Cheese	¾
Meats	10	Eggs, 1 dozen	1½
Fowl	3	Peanuts, 1 quart	½
Fish, fresh, lean	2		

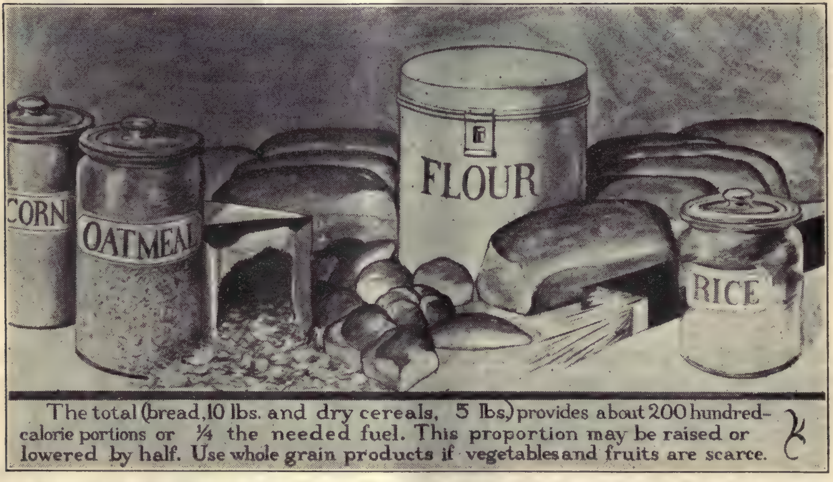
HOW TO ESTIMATE THE NUMBER OF HUNDRED-CALORIE PORTIONS OF EFFICIENT-PROTEIN FOODS.

The number of hundred-calorie portions that can be counted upon from the foods of the efficient-protein group is not easy to state except in the case of milk. A quart of whole milk supplies about 6 hundred-calorie portions and a quart of skim milk or buttermilk about 3 hundred-calorie portions. The 14 quarts of whole milk shown in Figure 2 represent, therefore, about 84 hundred-calorie portions. It has been found (see p. 18) that the meat exclusive of very fat products like bacon and salt pork, eggs, and similar foods used in most families average at least 8 hundred-calorie portions per pound.

The foods shown in Figure 2, some of which are fat and some lean, were chosen to correspond with this average and to supply about 112 hundred-calorie portions. It is true that the flesh foods, eggs, and cheese, used in the course of a week in a given family may represent less fuel than this per pound. They certainly will if they consist chiefly of fresh fish, chicken, or eggs, all of which are below the average in energy value. On the other hand, they will represent more than 8 hundred-calorie portions per pound if they consist chiefly of pork, lamb, cheese, or peanut butter, all of which are above the average. During the course of a month or a year, however, it is safe to count on an average of at least 8 hundred-calorie portions per pound from foods of this kind.

A WEEK'S SUPPLY OF CEREAL FOODS FOR THE AVERAGE, OR CENSUS, FAMILY.

A sample weekly supply of cereal foods for the average family is shown in Figure 3. This supply corresponds to about 12½ pounds of dry cereals, such as flour, meal, and ready-to-eat breakfast foods, and supplies about 200 hundred-calorie portions. It is believed that if this amount of cereal foods is used regularly in addition to the vegetables, fruits, milk, meat, and other foods illustrated, the diet will be sure to supply enough protein and the proportion of starch to sugar and fat will make it palatable. Many well-to-do families, however, prefer less cereals and more meat. The separate items are as follows:



The total (bread, 10 lbs. and dry cereals, 5 lbs.) provides about 200 hundred-calorie portions or ¼ the needed fuel. This proportion may be raised or lowered by half. Use whole grain products if vegetables and fruits are scarce.

FIG. 3.—Chart showing bread and other cereal foods which together supply about 200 hundred-calorie portions. Any other combination of cereal foods equivalent to 12½ pounds of dry cereal would furnish about the same amount of body fuel.

	Pounds.		Pounds.
Flour, 10 cups	2½	Ready-to-eat breakfast cereal, 5 to 6 cups	½
Rolled oats, 2½ to 3 cups	½		
Corn meal, 1½ cups	½		
Rice, 1 cup	½	Total	5
Macaroni	½	Bread and rolls	10

HOW TO ESTIMATE THE TOTAL AMOUNT OF CEREALS USED.

Some families make their own bread, some buy bread, and some buy part and make part. Every pound of bread contains approximately three-fourths of a pound of flour. The housekeeper can, therefore, make a rough estimate of the amount of cereal food she uses by adding three-fourths of the weight of bread she buys to the weight of the flour, oatmeal, and other dry cereal food she used in cooking. For example, in the foods illustrated in Figure 3 there are 10 pounds of bread and rolls representing three-fourths as much flour, or about 7½ pounds. This added to the 5 pounds of dry cereals makes a total of 12½ pounds.

HOW TO ESTIMATE THE NUMBER OF HUNDRED-CALORIE PORTIONS IN CEREAL FOODS.

It is a comparatively easy matter to estimate the number of hundred-calorie portions that are to be obtained from cereal foods. The dry cereals, including the various kinds of flours, meals, and breakfast foods average about 16 hundred-calorie portions per pound, and no one kind differs much one way or the other from the average. Bread and rolls average about 12 hundred-calorie portions per pound.

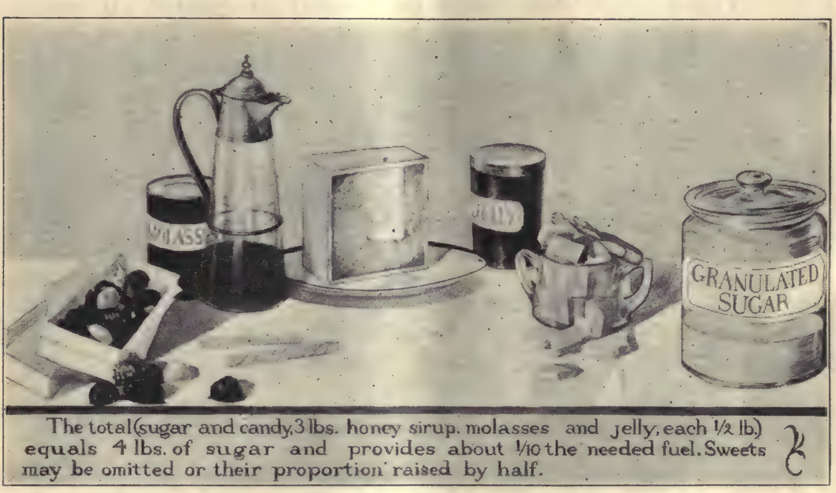

LASS
JELLY
GRANULATED SUGAR
The total (sugar and candy, 3 lbs. honey sirup. molasses and jelly, each ½ lb.) equals 4 lbs. of sugar and provides about 1/10 the needed fuel. Sweets may be omitted or their proportion raised by half.

FIG. 4.—Chart showing sugar and other sweet foods which together supply about 80 hundred-calorie portions. Any other combination of such foods which furnishes about 4½ pounds of sugar would furnish about the same amount of body fuel.

The dry cereals shown in Figure 3 may then be expected to furnish 5×16 hundred-calorie portions and the bread 10×12 hundred-calorie portions, making a total of 200 hundred-calorie portions. In this way the fuel value of any combination of cereal foods can be quickly ascertained.

A WEEK'S SUPPLY OF SWEETS FOR THE AVERAGE, OR CENSUS, FAMILY.

A sample weekly supply of sweets for an average, or census, family is shown in Figure 4. These sweets represent about 4½ pounds of sugar, or about 80 hundred-calorie portions. It is believed that this amount of sweets if used regularly will contribute to the attractiveness of the diet without interfering with the use of the required amount of protein, mineral substances, and vitamins. The separate items are as follows:

	Pounds.		Pounds.
Sugar, granulated, 4 cups	2	Sirup, about ⅔ cup	½
Sugar, loaf	¼	Molasses, about ⅔ cup	½
Candy	¾	Jelly	½
Honey, about ⅔ cup	½		

HOW TO ESTIMATE THE AMOUNT OF SUGAR IN SWEETS.

Granulated, lump, pulverized, and brown sugars, though differing in texture or flavor, are practically alike in composition; they contain little or nothing but sugar. A pound of candy may be considered the equivalent in fuel value of a pound of sugar. Water, which has no fuel value, is used in making candy, to be sure, but so, too, are chocolate and nut meats, which have higher fuel values than sugar. The average fuel value per pound of candies of various kinds is, therefore, about the same as that of sugar. The proportion of sugar in thick sirups, such as honey and molasses, is about three-fourths of a pound to the pound, and in jellies, jams, and rich preserves, about one-half of a pound to the pound. This makes it possible to estimate quickly the total amount of sugar used, whether in the form of sugar itself or in the form of candy, sirups, or preserves. For example, in the sweets shown in Figure 4 there are 2¼ pounds of sugar itself and three-fourths of a pound of candy, together corresponding to a total of about 3 pounds of sugar. The honey, sirup, and molasses together weigh 1½ pounds, of which about three-fourths, or 18 ounces, is sugar. The jelly weighs one-half pound, and of this about half, or 4 ounces, is sugar. The 5 pounds of sweets listed therefore contains about 4½ pounds of sugar.

HOW TO ESTIMATE THE NUMBER OF HUNDRED-CALORIE PORTIONS IN THE SWEETS.

Sugar itself provides 18 hundred-calorie portions per pound and average candy about the same number. Thick sirups provide about 13½ hundred-calorie portions, and jelly, jam, marmalade, and rich preserves about 9 hundred-calorie portions per pound. With these figures in mind, it is easy to estimate the number of hundred-calorie portions to be obtained from the sweets even when these foods are used in great variety. Of the sweets in Figure 4, for example, the 3 pounds of sugar and candy may be expected to furnish about 54 hundred-calorie portions, the 1½ pounds of thick sirups (honey, sirup, and molasses) about 20¼ hundred-calorie portions, and the one-half pound of jelly about 4½ hundred-calorie portions. This makes a total of nearly 80 hundred-calorie portions, or about one-tenth of the fuel needed weekly.

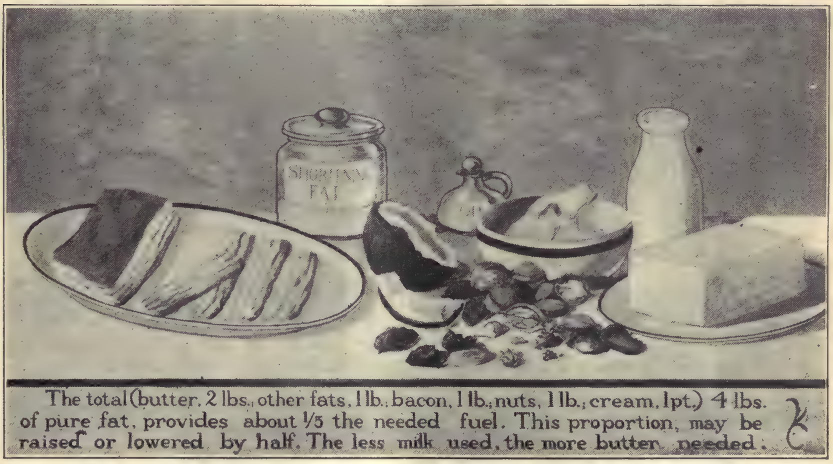
A WEEK'S SUPPLY OF FATS AND FAT FOODS FOR THE AVERAGE, OR CENSUS, FAMILY.

A sample weekly food supply of fats and fat foods for the typical family is shown in Figure 5. These foods correspond to about 4 pounds of pure fat and represent about 160 hundred-calorie portions. It is believed that this amount of fat, in addition to that supplied by the meat, milk, and similar foods suggested, will make the diet sufficiently rich to taste good. It is believed, also, that the amount of butter, cream, and suet shown will, if used in connection with the milk and green vegetables elsewhere recommended, be enough to keep up the supply of vitamin A. The separate items are as follows:

	Pound.		Pounds.		Pounds.
Oil, ½ cup	¼	Butter	2	Cream, 1 pint	1
Shortening fat, 1 cup	½	Bacon	1	Nuts in shell	1
Suet	¼				
Total	1	Total	3	Total	2

HOW TO ESTIMATE THE AMOUNT OF FAT IN THE FATS AND FAT FOODS.

Oil, suet, lard, and drippings may be considered to be all fat; butter, bacon, salt pork, chocolate, and fat nut meats may be considered to be at least three-fourths fat; and cream and nuts in the shell may be considered to be one-fourth fat. With these figures in mind it is possible to estimate the amount of fat in the fat foods, whether these foods are chiefly butter or chiefly cream, oils, nuts, or other foods commonly used to enrich the diet. For instance, the pound of oil, shortening fat, and suet, shown in Figure 5, may be considered all fat. The fat in butter and bacon may be considered to be about 2¼ pounds, or three-fourths of their total weight, while the fat in the cream and nuts in the shell may be considered to be 8 ounces, or one-fourth of their total weight. This makes a total of nearly 4 pounds of fat in all.



The total (butter, 2 lbs., other fats, 1 lb., bacon, 1 lb., nuts, 1 lb., cream, 1pt.) 4 lbs. of pure fat, provides about 1/5 the needed fuel. This proportion, may be raised or lowered by half. The less milk used, the more butter needed.

FIG. 5.—Chart showing fats and fat foods which together supply about 160 hundred-calorie portions. Any other combination of such foods equivalent to about 4 pounds of fat would furnish about the same amount of body fuel.

HOW TO ESTIMATE THE NUMBER OF HUNDRED-CALORIE PORTIONS IN THE FAT AND FAT FOODS.

Pure fat has a fuel value of about 4,000 calories per pound. Butter furnishes about 34 hundred-calorie portions per pound. Bacon, salt pork, chocolate, and fat nut meats average about 28 hundred-calorie portions, and cream and nuts in the shell about 10 hundred-calorie portions per pound. With these figures in mind it is possible to estimate quickly the number of hundred-calorie portions of fat and fat foods shown in the sample weekly supply as not far from 160 hundred-calorie portions, and the same method can be used in estimating the fuel value of any other list of fats and fat foods.

MEAL PLANNING.

Up to this point, emphasis has been laid on the kinds and proportions of foods in the weekly supply, and no mention has been made of the make-up of the separate meals. This was done in the belief that a balanced food supply insures a balanced diet. The common way of using such foods as those illustrated is by serving one or more foods from each of the five groups at each meal. Many people eat for breakfast: Fruit (Group I); either a cereal with milk, or an egg, or warmed-over meat or fish on toast or with bread (Groups II and III); butter or bacon (Group V); and sugar, marmalade, or both (Group IV). The usual bill of fare for lunch or supper includes meat, sliced cold or warmed over, or cheese, or eggs in some form, or a milk soup or chowder (Group II); bread or crackers (Group III); butter or oil (Group V); a green salad or sliced fruit (Group I); and sugar or a sweet of some other kind (Group IV). Dinner usually consists of meat, poultry, fish, or one of the so-called meat substitutes (Group II); potatoes and one other vegetable (Group I); bread and butter (Groups III and V); and a sweet of some kind for dessert (Group IV); or bread without butter (Group III) and a rich dessert (Groups IV and V).

Some housekeepers like to do a certain amount of "balancing" as they go along and to serve at least one food from each group at every meal, but this is not necessary. There is no objection in the case of an adult to a breakfast of toast, butter, and coffee, tea, or cocoa (chiefly Groups III and V), if enough vegetables, fruits, and efficient-protein foods are supplied at later meals. Nor is there any reason to think that serious injury would be done by the omission of any one group of food for a whole day, or even longer. For this reason, emphasis has been placed chiefly on the importance of keeping account of the foods served in the course of a week rather than of those in each meal.

Another point to be remembered is that meals are not necessarily well balanced, even if they contain representatives of all the food groups, for much depends on the proportions in which these foods are used. A dinner which includes meat, and also a dessert made of milk and eggs, such as custard or ice cream, is likely to supply far more of the efficient-protein foods than needed, an important matter since these are among the most expensive food materials. Nor is it possible to judge from the dishes served whether a meal is balanced or not. For example, a meal that includes no meat course, but has in its place only bread and butter with vegetables or fruits may be well-balanced if the dessert is such a dish as old-fashioned rice pudding which has milk for its chief ingredient. If the weekly food supply is satisfactory the exact make-up of the separate meals is not important, though the habit of providing all the required kinds of foods regularly is helpful and likely to save time and thought.

SUGGESTED BILLS OF FARE.

A bill of fare for a week that could be made from the food supply illustrated in Figures 1 to 5, is given below. It should be remembered that this food supply was planned for the average, or census, family and that it should perhaps be modified by increasing or decreasing the amount of milk according to the number of children and adults in the family. When more milk is provided for the young children this would partially take the place of the meat, fish, cheese, or egg dishes. It should be kept in mind also that the food materials in the suggested bill of fare are merely representative of the many kinds belonging to each group of foods. Thus, for example, pork, lamb, mutton, and veal might be substituted for chicken, fish, and beef, and many other fruits and vegetables might replace those enumerated with no loss of nutritive value and with the advantage of adding variety to the diet.

SUNDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Breakfast cereal with raisins and milk; eggs; bread or toast with butter.	Chicken,* stuffed and roasted or fricasseed and served on toast or with rice; sweet potatoes; asparagus; jelly; bread; ice cream.	Peanut sandwiches with lettuce salad; or bread, milk, and butter for children; candy.

MONDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Baked apples; breakfast cereal with milk; bacon; bread or toast with butter.	Scalloped canned fish; potatoes; sliced tomatoes; squash; bread and butter; strawberry shortcake.	Creamed dried beef with baked potatoes; bread and butter; sliced oranges with coconut.

TUESDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Sliced pineapple and bananas; breakfast cereal with milk; bacon; bread or toast with butter.	Curried lima beans with warmed-over chicken; macaroni and cheese*; cold slaw; bread; apple pudding, baked or steamed.	Creamed fish on toast or boiled rice; bread and butter; raisin tarts.

WEDNESDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Canned cherries; breakfast cereal with milk; eggs; bread or toast with butter.	Roast beef; boiled onions; potatoes; bread; peach pie.	Lime-bean chowder; crackers or bread and butter; celery; boiled rice with honey.

THURSDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Bananas; breakfast cereal with milk; eggs; bread or toast with butter.	Meat cakes*; creamed potatoes; string beans; bread; baked bananas.	Cheese sandwiches or scalloped cheese and rice;* lettuce; bread and butter; wheat cakes with sirup.

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* Bread and milk instead of this for young children.

FRIDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Stewed rhubarb; breakfast cereal with milk; corn griddle cakes with butter.	Fish, stuffed and baked;* sweet potatoes; beets with greens; bread; suet pudding with raisins.	Cream of pea soup; scalloped sweet potatoes; celery; bread or biscuits and butter; canned cherries.

SATURDAY.

BREAKFAST.	DINNER.	LUNCH OR SUPPER.
Canned peaches; breakfast cereal with milk; chipped beef on toast; bread or toast with butter.	Beef stew * or soup with turnips, carrots, onions, and dumplings; bread; orange custard with nut cookies.	Boiled potatoes and milk gravy made with bacon fat; cold slaw; bread and butter; candy.

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* Bread and milk instead of this for young children.

COMPARING ONE'S OWN FAMILY WITH THE AVERAGE, OR CENSUS, FAMILY.

The statement is made (p. 5) that the average, or census, family needs about 800 hundred-calorie portions a week, or about 114 a day. The number of hundred-calorie portions needed by any family can be estimated roughly by reference to Table 1, and from such an estimate the allowances for any given family or household may be compared with the allowances given in this bulletin. For illustration, in the case of the farm household suggested on page 5, each of the two men at hard muscular work would require about 300 hundred-calorie portions a week, the woman at similar work about 235, the two children in their teens about 535, and the younger child perhaps 140, making 1,510 hundred-calorie portions for the whole family. All of the allowances suggested in this bulletin, therefore, would need to be nearly doubled. The medium cereal allowance (see p. 10) would then be about 24 pounds a week instead of 12½, the fat allowance 8 instead of 4 pounds, and so on through the groups.

TABLE 1.—*Approximate number of hundred-calorie portions to be allowed for different individuals.*

Individual.	Per day.	Per week.
The average person over 12 years of age	27	200
A man or boy using large amount of muscular energy in work or play	40	280
A man or boy using moderate amount of muscular energy in work or play	33	235
A man or boy using little or no muscular energy in work or play	27	200
A woman or girl using large amount of muscular energy in work or play	33	235
A woman or girl using moderate amount of muscular energy in work or play	27	200
A woman or girl using little or no muscular energy in work or play	22	150
A boy or girl between 10 and 12 years of age	20	140
A boy or girl between 6 and 9 years of age	17	120
A boy or girl between 1 and 5 years of age	14	100
An infant under 1 year of age	6	40

COMPUTING THE COST OF A WEEK'S FOOD SUPPLY.

The amounts of foods given in this bulletin, namely, 70 pounds of vegetables and fruits, fresh weight, or 160 hundred-calorie portions of vegetables and fruits, fresh, canned, and dried; 14 quarts, or 84 hundred-calorie portions of milk; 14 pounds, or 112 hundred-calorie portions, of flesh foods, eggs, and cheese; 12½ pounds of cereal, dry weight, or 200 hundred-calorie portions of cereal foods; 4½ pounds of sugar, or 80 hundred-calorie portions of sweets; and 4 pounds of fat, or 160 hundred-calorie portions of fat foods may be depended on to supply enough fuel for the average, or census, family per week and to make an attractive diet. For economy's sake, however, it is often necessary to take into account the separate as well as the average values of the foods of the different groups. The fuel values in terms of approximate hundred-calorie portions of many of the common food materials as purchased are given in Table 2:

TABLE 2.—*Approximate number of hundred-calorie portions in common food materials as purchased.*

GROUP I. VEGETABLES AND FRUITS.

Materials.	Number of hundred-calorie portions.	Materials.	Number of hundred-calorie portions.
Vegetables, fresh:		Vegetables, canned—Continued.	
Asparagus	1 per pound.	Tomatoes	1¼ per No. 2 can.
Beans, lima, shelled.	5½ per pound.	Peas	2½ per pound.
Do	7 per quart.	Do	3 per No. 2 can.
Beans, string	1¾ per pound.	Vegetables, dried:	
Do	1½ per quart.	Beans	15½ per pound.
Beets	1½ per pound.	Cowpeas	15½ per pound.
Cabbage	1 per pound.	Peas	16 per pound.
Do	3 per medium-sized head (3 pounds).	Fruits, fresh:	
Carrots	1½ per pound.	Apples	2 per pound.
Cauliflower	1½ per pound.	Do	24 per peck.
Do	2 per medium-sized head (1½ pounds).	Bananas	3 per pound.
Celery	¾ per pound.	Do	11 per dozen medium-sized.
Corn	1¾ per pound.	Cherries	3½ per pound or per quart.
Do	11 per dozen medium-sized ears.	Cranberries	2 per pound or per quart.
Cowpeas, shelled	6 per pound.	Currants	2½ per pound or per quart.
Cucumbers	¾ per pound.	Grapes	3½ per pound or per quart.
Do	¼ per medium-sized cucumber.	Huckleberries	3½ per pound or per quart.
Lettuce	¾ per pound.	Lemons	1½ per pound.
Do	¼ per medium-sized head.	Do	4½ per dozen medium-sized.
Mushrooms	2 per pound.	Muskmelon	1 per pound or 1 per medium-sized.
Okra	1½ per pound.	Oranges	1¾ per pound or 10 per dozen medium-sized.
Onions	2 per pound.	Peaches	1½ per pound, 6 per dozen.
Parsnips	2½ per pound.	Pears	2½ per pound.
Peas	2½ per pound.	Plums	3¾ per pound.
Do	20 per peck.	Raspberries	3 per pound or per quart.
Potatoes, Irish	3 per pound.	Strawberries	1¾ per pound or per quart.
Do	45 per peck.	Watermelon	½ per pound.
Potatoes, sweet	4½ per pound.	Fruits, canned:	
Do	63 per peck.	Cherries	4 per pound.
Pumpkin	½ per pound.	Do	5 per No. 2 can.
Radishes	1 per pound.	Peaches	2 per pound.
Rhubarb	¾ per pound.	Do	2½ per No. 2 can.
Spinach	1 per pound.	Pears	3½ per pound.
Do	5 per peck.	Do	4½ per No. 2 can.
Squash	1 per pound.	Pineapples	7 per pound.
Tomatoes	1 per pound.	Do	4½ per No. 2 can.
Turnips	1¼ per pound.	Fruits, dried:	
Turnip tops	2 per pound.	Apples	13 per pound.
Vegetables, canned:		Dates	14 per pound.
Beans, string	1 per pound.	Figs	14½ per pound.
Do	1¼ per No. 2 can.	Prunes	11½ per pound.
Beans, baked	6 per pound.	Raisins	14 per pound.
Do	7 per No. 2 can.	Fruits, miscellaneous:	
Corn	4½ per pound.	Olives, green or ripe.	10 per pound or per pint.
Do	6 per No. 2 can.		
Tomatoes	1 per pound.		

TABLE 2.—*Approximate number of hundred-calorie portions in common food materials as purchased*—Continued.

GROUP II. FOODS DEPENDED UPON FOR EFFICIENT PROTEIN.

Materials.	Number of hundred-calorie portions.	Materials.	Number of hundred-calorie portions.
Dairy products:		Fish, fresh:	
Milk, whole	3 per pound or 6 per quart.	Bass	2 per pound.
Milk, skim	3 per quart.	Codfish	1½ per pound.
Buttermilk	3 per quart.	Halibut, steak	4½ per pound.
		Mackerel, Spanish	3½ per pound.
Milk, condensed, unsweetened	8 per pound.	Perch	2 per pound.
		Salmon	6 per pound.
Milk, condensed, sweetened	15 per pound.	Shad	3½ per pound.
Milk, dried, whole	23 per pound.	Shad roe	6 per pound.
Milk, dried, skim	16 per pound.	Smelts	2¼ per pound.
Cheese, ordinary	19½ per pound.	Trout, brook	2¼ per pound.
Cheese, cottage	5 per pound.	Fish, smoked or salted:	
Eggs	9 per dozen.	Cod, salt (boneless)	5 per pound.
Meats:		Halibut, smoked	9 per pound.
Beef, average	10 per pound.	Herring, smoked	7½ per pound.
Beef, chuck	7½ per pound.	Mackerel, salt	10 per pound.
Beef, corned	12½ per pound.	Fish, canned:	
Beef liver	5½ per pound.	Salmon	6½ per pound.
Beef ribs	11 per pound.	Sardines	9 per pound.
Beef, round	7¼ per pound.	Tuna fish	9½ per pound.
Beef, sirloin	9½ per pound.	Shellfish, fresh:	
Beef tongue	5½ per pound.	Lobster	1½ per pound.
Lamb, average	10 per pound.	Oysters	2 per pound.
Lamb, leg	11 per pound.	Do	4 per quart.
Lamb, loin	13 per pound.	Scallops	3½ per pound.
Mutton, average	12 per pound	Shellfish, canned:	
		Lobster	4 per pound.
Pork, whole side, average	22 per pound.	Shrimps	5 per pound.
		Legumes:	
Pork, except items in V, average	13 per pound.	Peanuts, unshelled	19 per pound.
Veal, average	5½ per pound.	Peanuts, shelled	11 per quart.
Poultry:		Do	25 per pound.
Chicken, broilers	3 per pound.	Peanut butter	27½ per pound.
Fowl	7½ per pound.	Soy beans, dried	20 per pound.

GROUP III. CEREAL FOODS.

Bread	12 per pound.	Macaroni	16 per pound.
Do	9 per loaf, 16 oz. dough, 12–14 oz. baked.	Oatmeal	18 per pound.
		Rice	16 per pound.
Cereals, flaked	15 per pound.	Rolls	12 per pound.
Corn meal	16 per pound.	Rolls, 2-ounce size	18 per dozen.
Crackers	19 per pound.	Tapioca	16 per pound.
Flour, wheat	16 per pound.	Wheat, shredded	16½ per pound.
Flour, buckwheat	16 per pound.		

GROUP IV. SUGARS AND SUGARY FOODS.

Candy, average	17 per pound.	Sirup, corn	54 per quart.
Honey	15 per pound.	Sirup, maple	49 per quart.
Do	55 per quart.	Sugar, granulated	18 per pound.
Molasses	13 per pound.	Sugar, maple	15 per pound.
Do	50 per quart.	Chocolate, milk	22½ per pound.
Sirup, corn	14½ per pound.	Chocolate, sweet	22 per pound.

GROUP V. FATS AND FAT FOODS.

Fats, table and cooking:		Nuts—Continued.	
Butter	34 per pound.		
Lard	41 per pound.	Butternuts, unshelled	4 per pound.
Oil	41 per pound.	Butternuts, shelled	32 per pound.
Suet	34 per pound.		
Cream, 18 per cent	9 per pound or per pint.	Coconut in shell, without milk	14 per pound.
Cream, 40 per cent	17 per pound or per pint.		
Fat meats:		Hickory nuts, unshelled	12 per pound.
Bacon	26 per pound.		
Pork, salt	28½ per pound.	Hickory nuts, shelled	33 per pound.
Pork sausage	21 per pound.	Pecans, unshelled	17 per pound.
Nuts:		Pecans, shelled	33 per pound.
Almonds, unshelled	16 per pound.		
Almonds, shelled	29 per pound.	Walnuts, California, unshelled	8½ per pound.
Brazil nuts, unshelled	16 per pound.	Walnuts, California, shelled	32 per pound.
Brazil nuts, shelled	32 per pound.	Chocolate	28 per pound.

From the figures in the table and from the market prices of foods, the cost of a hundred-calorie portion of any food can be determined, and the cost of the various foods that serve the same purposes in the diet can be compared. Take, for example, ordinary American cheese, which provides nearly 20 hundred-calorie portions per pound, and cottage cheese, which provides 5 hundred-calorie portions per pound. When the American cheese sells for 40 cents a pound it costs about 2 cents per hundred-calorie portion, and cottage cheese would have to sell for 10 cents a pound to be equally cheap as a source of energy. Bread, which furnishes 12 hundred-calorie portions per pound, costs about 1 cent per hundred-calorie portion when it sells for 12 cents a pound. To provide energy as cheaply, ready-to-eat breakfast cereals, which yield about 16 hundred-calorie portions per pound, would have to sell for 16 cents a pound, or for 5 cents for an ordinary 5-ounce package. It is often possible, too, to save money by changing the proportions of the foods from the average groups, and such changes are safe within certain limits. With the exception of the milk for children, the foods of any group may safely be increased or decreased by 50 per cent, and sweets may be omitted altogether, if desired.

Under most conditions of living the cheapest foods are the lower-priced cereal preparations, namely, flour, meal, and bread. Flour and meal seldom cost more than one-half cent per hundred-calorie portion, and baker's bread seldom costs more than 1 cent per hundred-calorie portion. One of the most satisfactory ways of reducing the cost of the diet, therefore, is by increasing the amount of cereal foods to 18 or 19 pounds a week for the average, or census, family, or until they supply 37½ per cent of all the fuel. When this is done, a few precautions must be observed. Care must be taken in the preparation of the cereals so that they will be palatable, and wisdom must be used in the selection of other foods. At least some of the cereals should be of the kind made from the whole grain, and the extra allowance of cereal foods must never be at the expense of milk or green-leaf vegetables. In general, too, extra care must be taken to select savory or flavorful foods from other groups when for economy's sake a comparatively large part of the diet is made up of cereals.

In figuring the relative costs of foods it must be remembered that a small saving per hundred-calorie portion may amount to considerable in the course of a week. For example, the 800 hundred-calorie portions usually consumed by the average family per week will cost $16 if the average price paid is 2 cents per hundred-calorie portion. If the average price can be reduced to 1½ cents per hundred-calorie portion, the cost of the week's food supply will be $12 instead of $16, a saving of $4.

SUGGESTIONS FOR A HOUSEHOLD FOOD ACCOUNT BOOK.

If the household food account book is so arranged that the items of the different groups are kept separate, it is easy to see whether the food supply is well proportioned and also to estimate the amounts of food used. Under each group there should be several subheads. For example, under vegetables and fruits, there should be at least two, one for fresh and canned, the other for dried. This will serve as a reminder that the original or fresh weight of the dried fruits was six times their dried weight, and that therefore 1 pound dried represents 6 pounds fresh weight. Most housekeepers will wish also to record separately fresh, canned, and dried vegetables, and fresh, canned, and dried fruits. In addition to this, it is well to list the green-leaf vegetables separately as a reminder of their importance in the diet. The section of the account book devoted to vegetables and fruits would then be arranged somewhat as shown below, and this would be typical of other groups as well.

HOUSEHOLD FOOD ACCOUNT BOOK.

GROUP I.—*Vegetables and fruits.*

FRESH GREEN-LEAF VEGETABLES.

Date.	Kind.	Amount.	Weight.	Cost.
Total				

OTHER FRESH VEGETABLES.

Total				

CANNED VEGETABLES.

Total				

DRIED VEGETABLES.

Total				

FRESH FRUITS.

Date.	Kind.	Amount.	Weight.	Cost.
Total				

CANNED FRUITS.

Total				

DRIED FRUITS.

Total				

Under Group II there should be at least two subheads, namely, (1) milk, and (2) flesh foods, eggs, and cheese. For convenience, however, the number of such foods may be increased to make separate records for milk; buttermilk and skim milk; eggs; fresh fish, dried fish, canned fish, meat, poultry, cheese, and peanuts.

Under Group III there should be at least two heads, namely, (1) dry cereals and (2) bread and rolls. This divides the foods that contain only three-fourths of cereal per pound from those that are all cereal. For convenience, a third subhead may be used, namely, (3) other bakery goods. These last-mentioned foods, which include cake, pie, doughnuts, and crackers, usually contain some fat and sugar, which raise their fuel value. They correspond more closely, therefore, in fuel value to the cereals themselves than to bread.

Under Group IV there should be three heads, namely, (1) sugar and candy, (2) honey, molasses, and sirups, each pound of which corresponds with about three-fourths of a pound of sugar, (3) jams, jellies, and preserves, each pound of which corresponds to about half a pound of sugar.

Under Group V there should be four heads, (1) fats, (2) bacon, salt pork, pork sausage, fat nut meats, chocolate, each pound of which corresponds to about three-fourths pound of fat, (3) butter and other table fats, each pound of which corresponds to about 13 ounces of fat, and (4) cream and nuts in the shell, each pound of which corresponds to about one-fourth of a pound of fat.

With this arrangement it is possible to estimate quickly the number of quarts of milk used and also the number of pounds of vegetables and fruits, fresh weight, of meats and similar foods, of cereals, of sweets, and of fat. With this arrangeemnt, too, the number of hundred-calorie portions used can easily be estimated with sufficient accuracy for most purposes. This can be done by allowing 2¼ hundred-calorie portions per pound for the fresh vegetables and fruits; 13½ per pound for the dried vegetables and fruits; 3 per pound or pint for the whole milk; 1½ per pound or pint for the buttermilk and skim milk; 8 per pound for the flesh foods, eggs, and cheese; 16 per pound for the dry cereals, and also for pies, cakes, and crackers; 12 per pound for bread; 18 per pound for sugar and candy; 13½ per pound for sirups; 9 per pound for jellies, jams, and marmalades; 40 per pound for fats; 34 per pound for butter; 28 per pound for bacon, salt pork, chocolate, and shelled nuts; and 10 per pound for cream and nuts in the shell.

Those who wish to compare the cost per hundred-calorie portion of different foods or to calculate the number of hundred-calorie portions provided by each separate food should add two more columns to the account. A sample section of the account book would then be arranged as follows:

GROUP II.—*Flesh foods, eggs, and cheese.*

Date.	Kind.	Amount.	Weight.	Cost.	Number of 100-calorie portions.	Cost per 100-calorie portion.
Total						

SUMMARY.

The problems of food selection considered in this bulletin come under four heads, namely, adequacy, wholesomeness, attractiveness, and cost. Of all the many food materials now available there is not one that can not be made to contribute in some way to the wholesomeness or to the attractiveness of the diet, but the number of different kinds of foods actually needed is small. All the food materials may in fact be classed under five heads or groups. Some of the members of each of the groups are shown in Figures 1 to 5 in such quantities that, taken together, they make a weekly food supply for the average, or census, family, consisting of a father, a mother, and three young children. Most of the common food materials that are not shown in the illustrations are included in the lists on pages 17 and 18, or mentioned in other parts of the bulletin. Since no two materials, even those that are grouped together, serve exactly the same purposes in the diet, attention is called to certain exceptionally important foods under each group that must not be omitted for any long period of time.

This grouping brings together under one head those foods which serve some, at least, of the same purposes in the diet, and which can therefore be reasonably compared in price. The amount of nourishment or of material other than water and inedible substances in a pound of each of the different foods is stated in two ways, by weight and by hundred-calorie portions. By means of either of these two methods of measuring food values the amount of nourishment obtained for a given sum of money in buying different foods at different market prices can be estimated and compared.

Suggestions are made for adapting the allowance of foods to the needs of families that require more or less food than the average family, and also for changing the proportions of the diet in the interest of economy.

NOTE.—Reproductions, in black and white, 18 by 23 inches, of the eight Food Selection and Meal Planning Charts referred to in this bulletin, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 50 cents a set.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1314

MOTOR TRUCKS ON CORN BELT FARMS

1862 1889

THIS BULLETIN is based on the experience of more than 500 grain and live-stock farmers located in the Corn Belt, each of whom has owned and used a motor truck over two years. It is designed to be of assistance to other farmers in the same region in determining whether or not they can use trucks profitably, and to assist men who already own trucks in determining whether or not they are using their machines as efficiently as others.

Washington, D. C. **Issued March, 1923**

MOTOR TRUCKS ON CORN-BELT FARMS.

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FARMS ON WHICH TRUCKS ARE OWNED.

REPORTS were sent to the Department of Agriculture in February and March of 1920, by over 1,000 farmer truck owners in Illinois, Indiana, Iowa, eastern Kansas, southern Minnesota, Missouri, eastern Nebraska, southeastern South Dakota, and southern Wisconsin. Each of these truck owners reported the size and type of his farm, the size of his motor truck, the length of time he had owned it, the use which he was making of it, the cost of operating it, and other related information. A complete analysis of the report from 831 grain and live-stock farmers is given in Department Bulletin 931, "Corn-Belt Farmers' Experience with Motor Trucks."

These reports covered the year of 1919, and at that time the prices of farm products were relatively high, farm labor was scarce and high in price, and in general conditions were favorable to the use of trucks by farmers. In order to determine whether farmers were continuing to use trucks during the period when prices were low and labor less valuable, each of these men who had given a report on his machine in 1920 was asked in February, 1922, for a statement as to whether he was still using his motor truck, and, if so, to give his idea of its profitableness under the conditions which prevailed at that time, to furnish information from which the cost of operating the machines under 1922 conditions could be computed, and for other related information which would be of assistance to farmers who do not own trucks in determining whether they can use them profitably at the present time, and, if so, the size and type which would probably be best suited to their conditions.

A total of 555 men replied to the request for information. The number in each State and the size of the farms which they were operating at the beginning of 1922 are given in Table 1. Each of these men is practicing the general grain and livestock farming characteristic of the Corn Belt. On every farm corn is one of the principal crops, and in most cases the raising and feeding of hogs is an important enterprise. Reports from farms where dairying is the principal enterprise are not included.

TABLE 1.—*The number of reports from different States, average size of farm, and average number of crop-acres per farm.*

State.	Number of reports.	Size of farm.	Crop-acres.	State.	Number of reports.	Size of farm.	Crop-acres.
		Acres.				*Acres.*	
Illinois	101	266	205	Eastern Nebraska	79	343	236
Indiana	34	279	213	Southeastern South Dakota	99	431	298
Iowa	142	284	232	Southern Wisconsin	11	242	173
Eastern Kansas	25	530	313				
Southern Minnesota	25	279	208	Total	555	......	......
Missouri	39	433	286	Average	......	334	242

Of the 555 men, 508, or 92 per cent, still owned the motor trucks on which they reported in 1920, and had used them in 1921.

Of the 47 men who no longer owned the trucks on which they originally reported, 21 had replaced them with others, and the remaining 26 had not purchased others.

SIZE OF FARM.

The average size of the farms on which these motor trucks are owned is considerably greater in each State than the average size of all farms. The 1920 census of agriculture shows that the average size of all farms in the States of Illinois, Indiana, Iowa, and Missouri is 135, 103, 157, and 132 acres, respectively.

In general, there will be more work for a truck on a large farm than on a small one, and a prospective purchaser should remember that if his farm is small the amount of hauling he will have for the motor truck will probably be less than that done by the men reporting.

DISTANCE TO MARKET.

Another striking point concerning the farms on which trucks are owned is their great distance from market as compared with other farms in the same section. A total of 475 men reported the distance from their farms to the markets which they used before purchasing trucks, and the average of these reports was 8 miles.

The proportion of the 475 farms at different distances from the markets used before trucks were purchased is as follows:

	Per cent.
Less than 5 miles	19
From 5 to 9 miles	50
From 10 to 14 miles	23
15 miles and over	8

A considerable number of these men have changed their markets since purchasing trucks, and are now using markets still further from their farms (see p. 7).

Farm survey records of other farms in different areas of the Corn Belt indicate that a majority of all Corn-Belt farms are less than 5 miles from market. The average distance from market of 2,213 Corn-Belt farms, as shown by records in the Office of Farm Management and Farm Economics of the Bureau of Agricultural Economics, is 3.9 miles, and the number at different distances is as follows:

	Number.	Per cent.
Less than 5 miles from market	1,535	69.3
From 5 to 9 miles from market	642	29.1
10 miles and over from market	36	1.6

These 2,213 farms can not be considered as exactly representative of all Corn-Belt farms, but a comparison of their distances from market with the distances from market of the farms on which trucks are owned shows clearly that most of the men whose reports form the basis for this bulletin have exceptionally long hauls.

FIG. 1.—The motor truck is most advantageous to the man who is far from market or shipping point.

The time required for hauling to and from the farm generally is greatest for those farmers farthest from market, and it is on such farms that most use will be found for motor trucks. (See Fig. 1.) One who is only 2 or 3 miles from market must have an exceptionally large amount of hauling if one expects sufficient work for a truck to make it a profitable investment.

SIZE OF TRUCK.

The number of trucks of different sizes on the 508 farms where the original trucks were still in use, the average size of the farms, and the average distances to the markets which were used before the purchase of trucks are given in Table 2. There is little difference in the size, and distance to market, of the farms on which the trucks of different sizes are owned, and evidently neither the size of the farm nor the distance to market had very much to do with the sizes of the trucks which the men purchased.

TABLE 2.—*Number of trucks of different sizes, size of farms on which they are used, and distance to market before trucks were purchased.*

Size of truck.	Total number.	Average size of farm.	Average crop-acres.	Average miles to market.
		Total acres.		
¾-ton	64	332	244	6.5
1-ton	348	323	235	8.1
1½-ton	57	363	266	8.1
2-ton	39	396	274	8.9
Total	508			
Average		334	242	8.0

ARE THESE TRUCKS PROFITABLE?

The method of conducting the investigation was such that it was not possible to determine the extent to which the use of motor trucks had changed the incomes of these men, but each one was asked the question "Do you believe this truck has been a profitable investment?" Each of the owners undoubtedly expected when he purchased his truck that it would prove a profitable investment, and the replies to this question should at least show the extent to which the trucks have not come up to the expectations of their owners. In all, 81 per cent of the men reporting in 1922 stated that they believed their trucks would prove profitable. A summary of the replies of the same men in 1920, two years earlier, showed that at that time 91 per cent believed their trucks would prove profitable.

That some of these men had changed their opinions during the two years between the reports was probably due both to the fact that as the trucks became older the cost of operating some of them had increased unduly, and furthermore that economic conditions in 1922 were not as favorable to the use of motor trucks as they were in 1920 and earlier.

The size of the trucks evidently had something to do with their owners' opinions as to their profitableness. In 1922, 84 per cent of the owners of the 1-ton and smaller sizes, and only 68 per cent of the owners of trucks of larger sizes believed their machines would prove profitable. In 1920, 92 per cent of the owners of the 1-ton and smaller sizes and 84 per cent of the owners of the larger sizes believed their trucks would prove profitable.

Practically all of these men, however, expected to continue to use their machines even though they did not believe they were proving profitable, 98 per cent of the 508 men who still owned their original trucks having stated that they expected to use them during 1922. In reply to the question as to whether they intended to buy others when their present machines are worn out, 85 per cent gave affirmative answers.

ADVANTAGES AND DISADVANTAGES.

There are many advantages in the ownership of a motor truck, but just how great these advantages are, and which should be given the greatest weight, are questions which the man who has not had experience with a truck can not answer. The important things for the prospective purchaser of a motor truck to know are what the men who have used trucks have found to be their principal advantages and disadvantages in actual practice. These motor-truck owners were asked the questions, "What is the principal advantage of a motor truck for farm use?" and "What is the principal disadvantage?"

In 1922, 93 per cent of the owners reported that the saving of time was the principal advantage, and in 1920, 90 per cent of the same owners gave the same reply. There are other advantages, of course, but evidently this is the principal one in the minds of truck owners. Very few report that the principal advantage of the truck is that it enables them to go to a better market, but 33 per cent of the total number now use other markets than before the purchase of their trucks. Going to a market which is farther from the farm is simply a matter of taking more time for marketing, and a considerable number of the men who say that saving of time is the principal advantage find that the truck saves them sufficient time to enable them to go to the better market. Reducing shrinkage when marketing live stock, which is often mentioned as one of the big advantages of a motor truck, is also largely a matter of reducing the time required for getting the stock from farm to market.

That such a small number consider other factors, such as the saving of horses, the reducing of expense, and added convenience, as the principal advantages of the truck, indicates that the amount of time which the motor truck will save, which may incidentally result in reaching a better market or getting live stock and crops to market in better condition, is the item which should be given paramount importance when considering the purchase of a motor truck.

As to the greatest disadvantage, in 1922, 58 per cent reported "poor roads"; 18 per cent "cost of operation"; and 9 per cent "first cost of the truck." Very few reported any other single item as the greatest disadvantage. In 1920, 54 per cent of these same men reported "poor roads"; 8 per cent "cost of operation"; and 8 per cent "first cost of the truck."

Most Corn-Belt truck owners are so situated that at least a part of the roads which they must use are unimproved and such roads are likely to be impassable for trucks at certain times of the year. (See p. 9.)

The cost of operation evidently was considered a more important disadvantage by truck owners in 1922 than in 1920. This doubtless was partly due to the fact that in 1922 the costs of repairs and of fuel and oil were higher with respect to the prices of farm products than they were at the date of the earlier report.

THE BEST SIZE.

That a man considers his motor truck a profitable investment does not mean, however, that he is entirely satisfied with the particular machine which he owns. It is very important that the truck should be of the proper size for the hauling which it is to do. Ordinarily both the first cost and the cost of operation of a small truck will be less than the costs of a large one, but often the small truck will not carry loads as large as desired, and more trips to haul a given amount of material will therefore be necessary than with a larger truck. A truck which is too large, however, would have to be operated with only a partial load a great part of the time, and the extra cost may more than offset the advantage of being able to carry larger loads on exceptional occasions. Accordingly each farmer was asked to state what size he considered best for his conditions, regardless of the size he owned.

It was found that in 1922, 66 per cent of these truck owners preferred the 1-ton size, 21 per cent the 1½-ton size, 9 per cent the 2-ton size, and 4 per cent the ¾-ton size. In 1920 the replies by these same men to the same question were as follows:

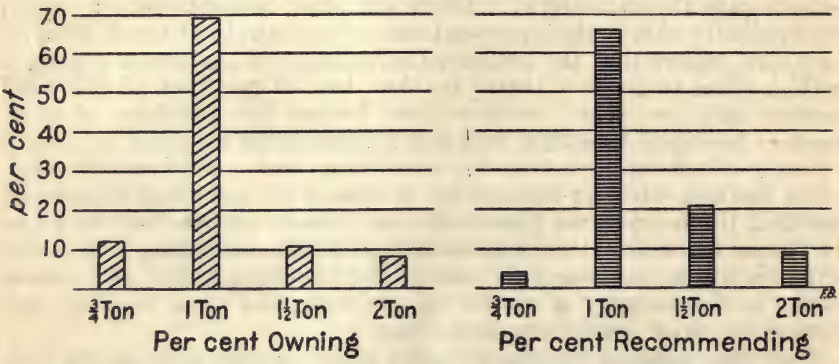

FIG. 2.—Sizes of motor trucks owned, and sizes recommended.

	Per cent.
1-ton size recommended by	57
1½-ton size recommended by	24
2-ton size recommended by	13
¾-ton size recommended by	6

Evidently the two years of additional experience has convinced a larger number of these men that a 1-ton truck is best for their conditions.

The proportion of those reporting who now own the different sizes of trucks, and the proportion who in 1922 preferred trucks of certain sizes, are shown in Figure 2. It is apparent that the choice of a truck for a Corn-Belt farm similar in size, type, and distance from market to farms operated by the men reporting, should in a large majority of cases lie between the 1-ton and the 1½-ton sizes.

CHANGE OF MARKETS.

Many farmers who do not own trucks are using first-class markets, and there are many whose farms are so located that even motor trucks will not put such markets within reach. However, about 33 per cent of the truck owners reporting in 1922 have changed since purchasing trucks to markets farther from the farms, and the primary reason for the change was that the new market is better than the old one.

The men who have changed markets are on an average 7 miles from the markets they used before purchasing trucks, and 16 miles from the markets which they now use. Before purchasing trucks 73 per cent of them were using markets less than 10 miles distant, but now 64 per cent are using markets 10 miles or more from their farms. About one-fourth go to markets which are 20 miles or more away.

The fact that a man has changed his market since the purchase of his truck does not necessarily mean that he hauls all of his produce to the new market, or that he hauls all of his supplies for his farm from that place. A considerable number of the men who reported a change of market still do some hauling to and from the market which they used before trucks were purchased.

A few of the men who in 1920 reported that they had changed markets stated in 1922 that they were no longer using the new market, but were marketing all of their produce at the place which they used before purchasing trucks. Such men had found that under the conditions existing at the time of their later reports the advantage of the new market was not sufficient to pay for the extra time and expense required to reach it, even with the motor truck.

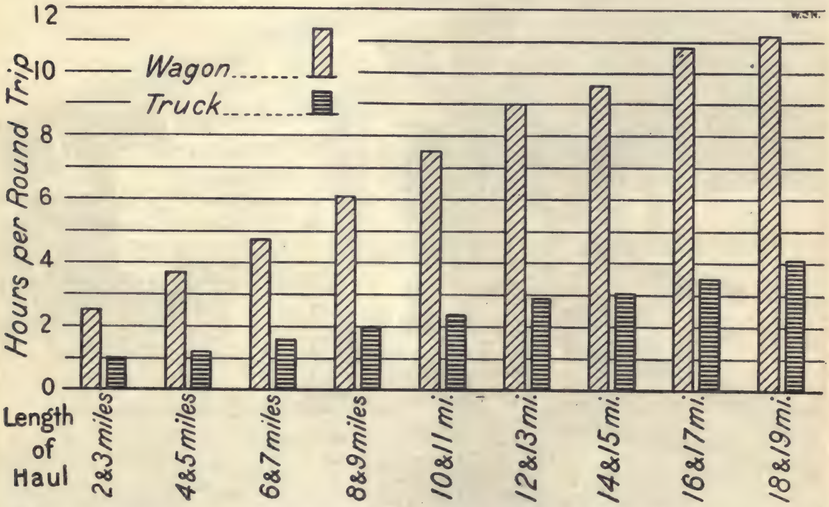

FIG. 3.—Comparison of time required for hauling different distances with wagons and with trucks.

ROAD HAULING WITH TRUCKS.

Figure 3 shows the time required for the round trip when hauling different distances with wagons and with trucks as reported by about 500 Corn-Belt truck owners in 1920. The truck owners were not asked to give this information in their later reports. The time shown includes the time required for loading and unloading the wagon or truck. For each distance the time required with trucks is something like one-third that required with horses and wagons. (See Fig. 4.)

This chart will give the prospective purchaser a definite idea of the amount of time the truck will save him provided he expects to haul with the truck loads of the same size as he has hauled with his horses and wagon. As a matter of fact, the owners of the 1½-ton and 2-ton trucks reported that on the average they hauled considerably larger loads of crops and live stock with their trucks than with horses and wagons, while the owners of the 1-ton and ¾-ton trucks hauled loads of approximately the same size as with wagons.

RETURN LOADS.

The percentage of time which a truck is run without load has a direct bearing upon the cost per unit of hauling with it. If an owner can arrange to haul a load to market and then bring back a load of supplies to his farm on the same trip he can reduce the time required and expense by practically 50 per cent. The 1920 reports, as summarized in United States Department of Agriculture Bulletin 931, showed that the truck owners reporting at that time had return loads for their trucks about 34 per cent of the time. About 10 per cent stated that they never had return loads. Apparently the size of the truck and distance from the farm to market had little to do with the percentage of the time return loads were available.

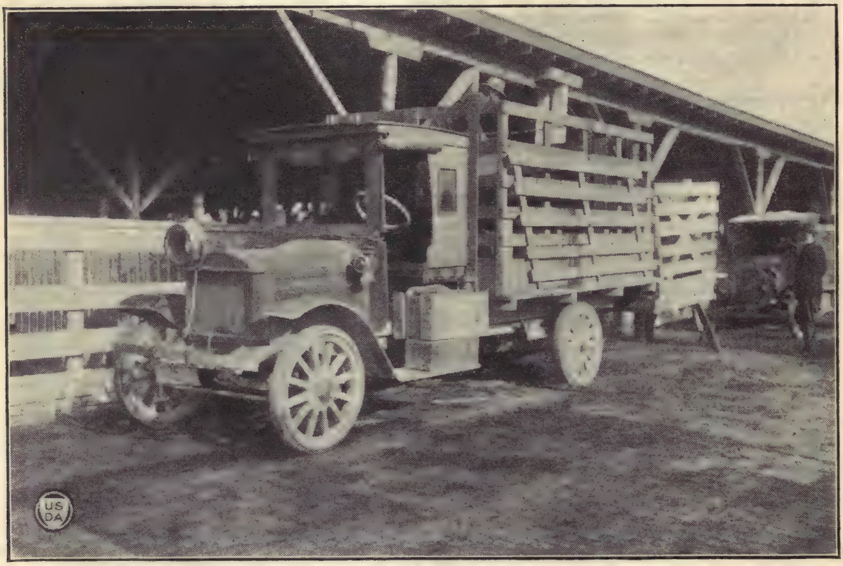

Fig. 4.—Unloading hogs at stockyards from farm-owned truck. Motor trucks enable many farmers to haul live stock direct to central markets which are too far away to be reached with horses and wagon.

ROAD HAULING FOR WHICH TRUCKS ARE NOT USED.

A little over half the men reporting in 1922 stated that they used their horses to supplement their trucks in hauling on the road during the preceding year. These men who had used horses had done on the average about 17 per cent of their total road hauling with them, and the remaining 83 per cent with their trucks. On this basis for all farms reporting 8 per cent of the road hauling had been done with horses and 92 per cent with trucks.

Most of these men use horses only for road hauling which must be done when the roads are in such a condition that trucks can not be used, or for hauling material which the body of the truck is unsuited to carry. In 1920 the men who used horses were asked to state the reason for so doing. Seventy-one per cent of those replying at that time gave "poor roads" as the reason, and 14 per cent gave as the reason that the truck body was unsuitable for the material to be hauled.

EFFECT OF DIFFERENT KINDS OF ROADS ON USE OF TRUCKS.

Poor roads, in the minds of most men who own trucks, are the greatest disadvantage connected with their use, and poor roads are largely responsible for the continued use of horses for part of the road hauling. In the 1920 investigation each truck owner was asked to specify the kind of roads over which his truck traveled and the number of weeks during the preceding year the roads had been in such condition on account of mud, snow, ice, or frost that the truck could not be used. The replies should give the prospective purchaser a definite idea of the difficulties he is likely to experience in this respect.

All kinds of roads, from unimproved dirt roads to high-class highways, were reported. However, 80 per cent of the men who reported on this point stated that their trucks ordinarily travel only on dirt roads. 14 per cent stated that the roads which they ordinarily use are part dirt and part improved, and the remainder stated that they have only improved roads, either gravel, macadam, or better.

On the average there were 8.4 weeks during the year when the trucks could not be used, and only about 6 per cent of the men reported that they were able to use their trucks every week. The men whose trucks usually travel on improved roads only, however, were prevented from using them but five weeks during the year, and over one-fourth were able to use them every week.

The reports indicate that poor roads are not such a great handicap to pneumatic-tired trucks as to those equipped with solid tires. About 10 per cent of the men who have pneumatic-tired trucks were able to use them every week in the year, and less than 30 per cent were laid up for more than 8 weeks by poor roads. Less than 2 per cent of the men whose trucks were equipped with solid tires were able to use them every week, and over 45 per cent of them were laid up for more than 8 weeks.

HAULING ON THE FARM WITH TRUCKS.

Most of the work which these farm-owned trucks do is hauling on the road, but often a truck can be used to advantage for some of the hauling on the farm itself—that is, in the fields and around the buildings. About 70 per cent of the men reporting in 1922 stated that they used their trucks for some of this hauling, while the remaining 30 per cent stated that they did it all with horses.

Most of the time required for hauling on the farm is taken up with loading and unloading, and the percentage of the total time which could be saved by the truck when used for such work is small as compared with the time it saves in road hauling. The smaller trucks sometimes will not carry loads as large as it is desired to haul, and sometimes the bodies with which they are equipped are not suitable for the material to be hauled about the farm. In many cases the truck can not obtain traction in the field. When horses which would otherwise be idle are available it would naturally be more profitable to use them if there is no advantage or convenience in using the truck.

However, when the vehicle must be left without attention for a considerable length of time, or if frequent stops are to be made, it may be preferable to use the truck, and the truck may save considerable time in hauling about the farm if the farm is large and satisfactory roadways are available. (See Fig. 5.) It may also save time to use the truck when only one or two loads are to be hauled, and wagons and horses are not ready for work.

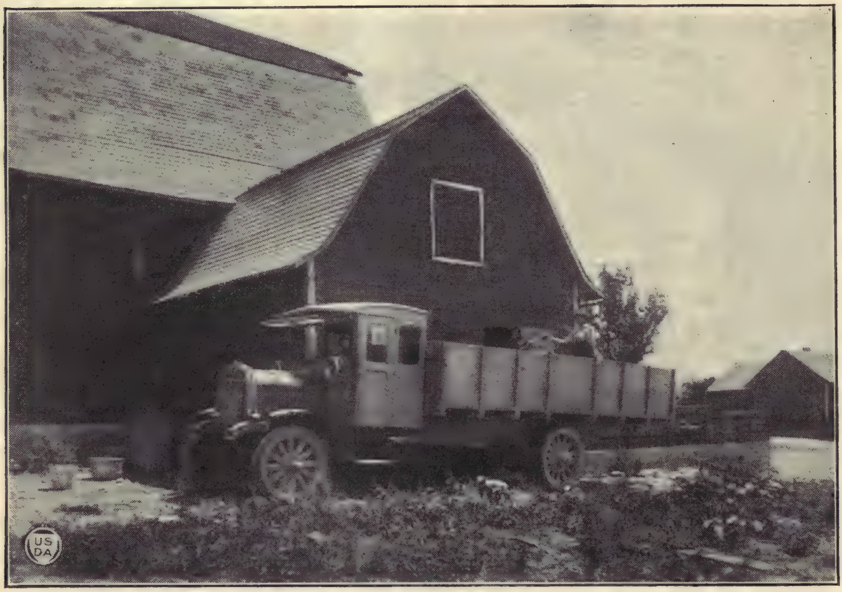

FIG. 5.—Unloading grain from a truck. The motor truck can often be used advantageously for hauling grain from the separator to the granary.

CUSTOM HAULING.

While all of the men whose reports form the basis of this bulletin used their trucks primarily for their own hauling, about 37 per cent did some hauling for hire during the year preceding the time of reporting. The men who did custom hauling were also asked what percentage of the total time the trucks were used during the year was spent in custom hauling, and it was found that for those who did such work custom hauling amounted to about 15 per cent of the total time the trucks were used. Nearly all truck owners doubtless have opportunities to do custom hauling with their machines if they desire to do so, but a farmer can not often afford to neglect the work on his own farm to do work for neighbors. However, if his whole time is not fully occupied, a truck owner can easily increase his income by hauling for hire. Many of these truck owners stated that the principal reason for doing custom hauling was to accommodate their neighbors, and often in such cases the charge for it was too low to make the work profitable.

ANNUAL USE OF TRUCKS.

The number of miles per year which a truck travels has a direct bearing upon the cost per mile run and per ton hauled, and the prospective purchaser should give careful consideration to the amount of use which he will have for his truck. The amount of material to be hauled, the size of the truck, and the length of haul will all have an influence on the distance per year which a truck will travel. Depreciation, interest, and repairs are all more or less independent of the number of miles which the truck travels per year, and the greater the number of miles traveled or the greater the amount of material hauled the less will be the charge per mile run or per ton hauled for these items.

The distances which their owners estimated these trucks traveled in 1921 are shown in Figure 6. The average distance traveled per year, according to these estimates, is 1,987 miles.

These men also estimated the number of days per year on which they use their trucks—not the number of full days' work which the truck does, but simply the number of days on which some use is made of it—and the average of these estimates was 72 days for 1921. Thus the trucks traveled on the average about 28 miles each day on which they were used. On the average ¾-ton trucks were used 88 days and traveled 2,765 miles during the year; 1-ton trucks were used 72 days and traveled 1,820 miles during the year; 1½-ton trucks were used 59 days and traveled 2,111 miles during the year; 2-ton trucks were used 68 days and traveled 2,035 miles during the year.

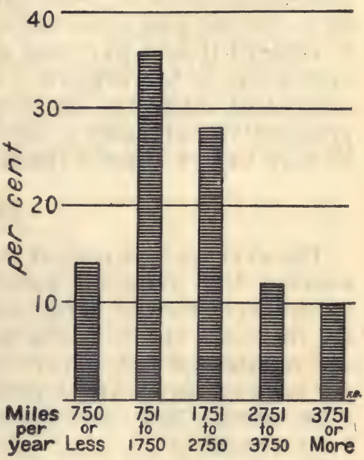

FIG. 6.—Percentage of motor trucks which travel different distances per year.

As shown in Figure 6, about 14 per cent of the trucks traveled 750 miles or less during the year. This is a very low utilization for a machine so expensive and capable of doing so much more work. The cost per mile run and per ton hauled with the truck would necessarily be very high on these farms, and it is doubtful if a truck which travels no more than 750 miles a year can often save its owner enough time to make it a profitable investment.

COST OF OPERATION.

FIRST COST.

The average first cost of the trucks of different sizes, including extra equipment purchased for use with them, was: For ¾-ton trucks, $1,486; for 1-ton trucks, $987; for 1½-ton trucks, $1,943; for 2-ton trucks, $2,115.

Often the quoted price of a truck does not include some equipment which it is necessary or desirable to have, and about two-thirds of the men reporting had purchased some such equipment This varied from minor attachments, costing only $2 or $3, to cabs and bodies costing several hundred dollars. It must also be remembered that practically all of these trucks were purchased in 1917, 1918, or 1919, and that the price of motor trucks in general was at that time higher than the prices which now (June, 1922) prevail.

LIFE.

The average life of these trucks, as estimated in 1922 by their owners, is 8.4 years. The estimated life of the ¾-ton trucks is 7.9 years, 1-ton trucks 8.3 years, 1½-ton trucks 9 years, and 2-ton trucks 8.3 years.

The estimate of the life of a truck depends not only upon the probable amount of work which it will do and the care which it will be given, but also upon the owner's idea as to when it will be cheaper to discard it and purchase a new one than to spend more time and money on it for repairs. There is quite a wide variation in the individual estimates on this item, but the averages will give the prospective purchaser a fairly definite idea of the amount of service he may expect from a truck.

DEPRECIATION.

The average first cost of the trucks of different sizes divided by the average life gives an annual depreciation of $188 for the ¾-ton trucks, $119 for the 1-ton trucks, $216 for the 1½-ton trucks, and $255 for the 2-ton trucks. The annual depreciation divided by the average number of miles traveled per year gives a depreciation charge per mile of travel of 6.8 cents for the ¾-ton trucks, 6.5 cents for the 1-ton trucks, 10.2 cents for the 1½-ton trucks, and 12.5 cents for the 2-ton trucks.

The depreciation per year and per mile varies greatly for individual trucks, but these average figures at least show the importance of this item. For each size the depreciation charge as here given is greater than the combined costs of fuel, oil, and tires (see p. 15).

REPAIRS.

The repair costs vary greatly with individual trucks, but the prospective owner will desire to know something as to what he must expect. Repairs will ordinarily be low for the first year or two of the truck's life. Of the men who furnished reports in both 1920 and 1922, 472 gave on their first reports the amount which they had spent up to that time for repairs, and 431 gave on their second report in 1922 the amount which they had spent up to that time for repairs.

Of the 472 reporting in 1920, 100 had owned their trucks 6 months or less, and 68 of the 100 had spent nothing for repairs, while the average cost of repairs for the 32 had been about $13; 166 had owned their machines from 7 to 12 months, and 92 had no repairs, while the average cost for the 74 had been about $13; 184 had owned their machines 13 to 24 months, and 40 had no expense for repairs, while the average cost for the 144 had been about $29; 22 had owned their machines 25 months or more, and as all had spent something for repairs the average cost was about $33.

At the time the 1922 reports were made, all of the machines had been in use more than two years. Of the 431 who reported their repair costs at that time, 246 had owned their machines 25 to 36 months, and the average repair cost from the time of purchase had been $47; 160 men had owned their trucks 37 to 48 months, and the average repair cost from the time of purchase had been $80; 25 men had owned their trucks more than 48 months, and the average repair cost had been $82.

There were wide variations in the repair costs of individual trucks of the same size and age, but in general it is to be expected that the repair costs will be higher for the larger trucks, and that they will increase as the trucks become older.

On the average, the trucks which had been in use between 3 and 4 years, with an average total repair cost of $80, had an average annual repair cost of approximately $25, but it is evident that the average annual repair cost for the entire life of these trucks would be higher. In the absence of more accurate figures, allowances of $75 per year for the ¾-ton trucks, $75 for the 1-ton trucks, $100 for the 1½-ton trucks, and $150 for the 2-ton trucks have been made as fair charges for the average annual repair costs in figuring the cost of operation. (See p. 15.)

GASOLINE AND OIL.

The average number of miles per gallon of gasoline obtained by men who own trucks of different sizes is about 11.2 miles for the ¾-ton, 10.5 miles for the 1-ton, 9.1 miles for the 1½-ton, and 7.9 miles for the 2-ton trucks. There is practically no difference between the 1920 and the 1922 reports as to the average number of miles per gallon of fuel for the different sizes. The average number of miles per quart of lubricating oil for the machines of different sizes as reported in 1920 was 80 miles for the ¾-ton, 46 miles for the 1-ton, 52 miles for the 1½-ton, and 38 miles for the 2-ton trucks. Since lubricating oil is one of the minor items of expense, the owners were not asked to report concerning it in 1922.

The price of gasoline to farmers in the Corn Belt is at present (June, 1922) about 22 cents per gallon. The average price of lubricating oil of the quality used by these men is something like 65 cents per gallon. On this basis the total cost per mile for gasoline and lubricating oil for the trucks of different sizes would be 2.2 cents for the ¾-ton, 2.5 cents for the 1-ton, 2.7 cents for the 1½-ton, and 3.2 cents for the 2-ton trucks.

TIRES.

Tire costs vary, of course, for trucks of different sizes, depending upon whether solids or pneumatics are used and to a certain extent upon the quality of the tires and upon the number of miles traveled per year. In the 1920 investigation each truck owner estimated the number of miles which his tires run and gave the price which he paid for them. According to the estimates of 310 men given at that time, pneumatic tires run on an average 4,400 miles, and the estimates of 161 men showed that solid tires run 7,700 miles. At that time 24 per cent of the trucks on which reports were received were equipped with pneumatic tires, 27 per cent with solid tires, and 49 per cent with pneumatics in front and solids in rear.

A comparison of the present (June, 1922) prices of truck tires with the 1919 prices shows that in 1922 the first cost of pneumatic tires similar to the ones with which these trucks are equipped is about 70 per cent of the 1919 costs, while solid tires are about 80 per cent of the 1919 costs. The cost per mile of pneumatic tires for all sizes of trucks, as given in Table 3, was obtained by taking 70 per cent of the 1919 costs.

AVERAGE COST PER MILE.

The average cost of operating trucks of different sizes is shown in Figure 7 and Table 3. The items included are depreciation, repairs, interest on investment, registration and license fees, gasoline and oil, and tire cost.

The figures for annual depreciation are obtained from page 12 and those for repairs from page 13.

Interest is figured at 8 per cent on the average investment. The average investment has been found by the rule: Average investment equals the first cost multiplied by years of service plus 1, and this result divided by years of service multiplied by 2. This is the generally accepted method for determining the average investment in equipment where a fraction of the first cost is charged off each year for depreciation. The interest charge, when computed on this basis, is slightly greater than when computed on half the first cost.

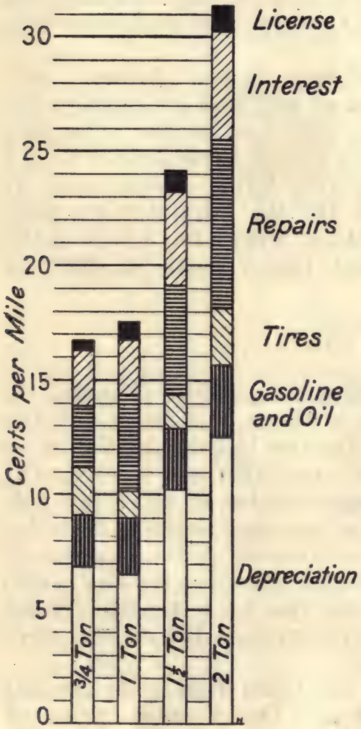

FIG. 7.—Cost per mile of operating trucks of different sizes.

The registration and license fees are the averages for the year 1922 in the States covered by the investigation. There is considerable variation in these fees for trucks of the same size in different States. They range from $6 for the small trucks in Missouri and Indiana to $35 for the 2-ton trucks in South Dakota.

The number of miles traveled per year, the gasoline and oil costs, and the tire costs are all discussed above. The tire costs used are those for pneumatic tires for each size. In no case is the average cost for solid tires more than 1 cent per mile different from the pneumatic-tire costs.

No charge has been made for taxes, insurance, housing, grease, inner tubes for pneumatic tires, or for labor spent in caring for the truck. However, these charges would ordinarily amount to a very small portion of the total cost of operation.

TABLE 3.—*Cost of operating trucks of different sizes.*

	Size of truck.			
	¾-ton.	1-ton.	1½-ton.	2-ton.
Fixed charges:				
Annual depreciation	$188	$119	$216	$255
Annual repairs	75	75	100	150
Annual interest	67	44	86	95
Annual registration and license fees	12	14	19	25
Total fixed charges	342	252	421	525
Miles traveled per year	2,765	1,820	2,111	2,035
Fixed charges per mile	$0.124	$0.138	$0.199	$0.258
Gasoline and oil per mile	.022	.025	.027	.032
Tires per mile	.021	.012	.015	.024
Total cost per mile	.167	.175	.241	.314

COST OF HAULING WITH TRUCKS.

The cost of hauling with a motor truck is determined by the cost of operating the truck, the charge for the driver's time and labor, the size of load hauled, and the percentage of time the truck runs without a load. In Table 4 are given the cost per mile of haul and the cost per ton-mile for hauling crops with trucks of different sizes. The cost of operating the truck is taken directly from Table 3. The charge for the driver is obtained by allowing a rate of 25 cents per hour for his time while driving and while loading and unloading the truck. The average time required for hauling, as given by the truck owners in 1920, was 0.12 hour per mile of travel for each size of truck.

TABLE 4.—*Cost of hauling crops with trucks of different sizes.*

	Size of truck.			
	¾-ton.	1-ton.	1½-ton.	2-ton.
Truck cost per mile run	$0.167	$0.175	$0.241	$0.314
Charge for driver per mile run	.030	.030	.030	.030
Total	.197	.205	.271	.344
Cost per mile of haul (33 per cent idle running)	.294	.306	.404	.514
Cost per ton-mile for hauling crops	.221	.234	.232	.234

It is stated on page 8 that these men have return loads for their trucks about 34 per cent of the time; that is, each truck hauls loads both ways on 34 out of every 100 round trips it makes from and to the farm, and runs without a load 66 one-way trips. The cost of operating the truck and the value of the driver's time for these 66 trips with no load must be charged to the 134 trips with loads, in order to obtain the actual cost per mile of haul. Every 134 miles of haul, then, must bear the expense of 200 miles of travel, or every 67 miles of haul must bear the expense of 100 miles of travel. The cost per mile of haul as given in Table 4 is obtained by multiplying the total cost per mile traveled by 100 and dividing the product by 67.

The cost per ton-mile hauled is determined by dividing the cost per mile of haul by the weight of the load in tons. The average weight of the load of crops hauled with the ¾-ton trucks as given by the truck owners in 1920 was 1.33 tons, for the 1-ton trucks the average load was 1.31 tons, for the 1½-ton trucks 1.74 tons, and for the 2-ton trucks 2.2 tons. The cost per mile of haul for the trucks of different sizes divided by these figures gives the cost per ton-mile. Figure 8 shows the proportion of the total cost of hauling with trucks of different sizes chargeable to the driver and the proportion chargeable to the truck.

RELIABILITY.

The reliability of a motor truck, as that of any other machine, has a very decided effect upon its profitableness. If a truck is out of commission for several days at a time when its services are needed and when its owner is depending upon it to help him through a busy time, it can scarcely be considered a profitable machine for him to own.

In order to afford prospective purchasers information as to the reliability of motor trucks for farm use, these truck owners were asked both in 1920 and in 1922 to give the number of days their trucks had been out of commission when needed during the preceding year.

In 1922, 492 of the 508 men who were still using their original trucks gave the number of days they had been out of running order when needed in 1921. Three hundred and seventy-four of the trucks, about three-fourths of the entire number, had always been ready for work when needed, 79 had been out of order for 5 days or less, and the remaining 39 for 6 days or more. None of these trucks had been in use less than two years at the time the reports were made. Four hundred and seventy-five of the same men had given in their previous reports the number of days their trucks were out of order during 1919. Evidently there is a somewhat greater likelihood of a truck getting out of running order as it becomes older, as the earlier reports show that 415, or about 87 per cent, of the machines had always been ready for work when needed during the year covered by the earlier reports.

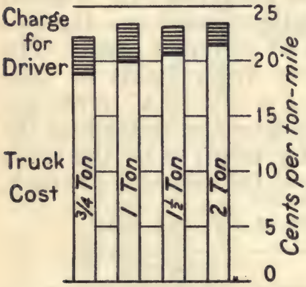

FIG. 8.—Cost per ton-mile of hauling crops with trucks of different sizes.

To a certain extent the reliability of a motor truck, as of any other complicated machine, depends upon the ability of the operator and the care which the machine is given. Most of these trucks are operated by their owners, or some member of the family, and it is to be expected that the owner of such an expensive machine as a motor truck, or any member of his family, would give it a reasonable amount of care, and at least endeavor to operate it intelligently. Furthermore, automobiles are owned on a large majority of these farms, and tractors on 55 per cent of them. Thus nearly all the men who drive the trucks have doubtless had considerable experience in the operation of similar machines. The exceptionally small amount of trouble which these trucks have given is doubtless due in part to these facts.

SAVING OF HIRED HELP.

The saving of time is given by these men as the greatest advantage in the use of a motor truck; but the saving of time will not be of any financial benefit to a farmer unless he uses the time thus saved on other work, or unless it enables him to reduce the expense for hired help. In the 1920 investigation, each truck owner was asked whether or not his truck reduced the expense for hired help, either man or horse, and if so, to estimate the amount thus saved during the preceding year. The replies, as summarized in Department Bulletin 931, show that of 783 men who answered the question, 612, or 78 per cent, said that the truck reduced this expense, and the remaining 171 that it did not.

Three hundred and eighty-five of the 612 estimated the amount thus saved, and the average of these estimates was $209. The wages of farm laborers were considerably higher at that time than at present (June, 1922), and on the basis of 1922 wages this average saving would be between $100 and $150. This figure can scarcely be taken to represent the actual amount which the labor bills of these men have been reduced since purchasing their trucks, but rather as their estimates of the amounts by which their bills would be increased if they did not now own trucks and if they were doing the same amount of work they are now doing.

There was little difference in the percentage of the owners of trucks of different sizes who said that their trucks reduced the expense for hired help, or in the amounts which they estimated the trucks saved.

DISPLACEMENT OF HORSES.

If the organization of a farm is such that some work stock must be kept primarily for hauling on the road, the purchase of a truck should enable the farmer to dispose of such work stock and reduce his expenses correspondingly. On most Corn Belt farms, however, the work stock which it is necessary to keep in order to carry on the field work satisfactorily can also do all of the hauling on the road.

The truck owners were asked in 1920 to report the number of work stock they were keeping at that time and the number they had disposed of since purchasing their trucks. They were also asked in 1922 for the number of work stock kept, and 382 of the 508 owners gave complete reports on their work stock in both years. In 1920, 160, or about 42 per cent, stated that they had reduced their work stock by an average of 2½ head after purchasing their trucks, and the remaining 222, about 58 per cent, stated that they were keeping the same number as before. There had been practically no further reduction between 1920 and 1922, as the 382 men were keeping an average of 8.3 head in 1920 and 8.1 head in 1922.

FARMS ON WHICH BOTH TRUCKS AND TRACTORS ARE OWNED.

In 1922 tractors as well as motor trucks were in use on 55 per cent of the farms from which reports were received. In 1920 tractors were in use on 50 per cent of these same farms. Most of the tractors were owned on the larger farms. There was an average of 258 crop-acres on the farms where tractors were in use in 1922, and 214 crop-acres on those farms where tractors were not in use. The men who owned tractors as well as motor trucks kept an average of 8 head of work stock on each farm, one for every 32 crop-acres, while the men who did not own tractors kept an average of 8.2 head, one for each 26 crop-acres.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1315

CLEANING MILKING MACHINES

MILKING MACHINES are playing a larger and larger part in the economics of dairying. For this reason care must be taken in sanitation, so that nothing will impede their continued and increasing use.

Milking machines must be thoroughly washed and sterilized if clean milk of a low bacterial content is to be produced.

The Department of Agriculture is conducting investigations in the cleaning of milking machines, and from experience gained so far has found the method outlined in this bulletin to be both simple and effective.

The method applies particularly to machines of the vacuum-pipe-line type, in which the milk is drawn through rubber tubes. The same principle of cleaning applies to other types, but it may be necessary to vary details.

Washington, D. C. **Issued March, 1923**

CLEANING MILKING MACHINES.

By L. H. BURGWALD, *Assistant Market Milk Specialist, Dairy Division.*

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NECESSITY FOR PROPER CLEANING.

THE use of mechanical milkers is becoming more common in the production of market milk, and the extension of their use brings up the problem of keeping the machines clean. Unsterile dairy utensils are one of the chief means by which fresh milk is contaminated by bacteria. For this reason each additional piece of apparatus with which milk comes in contact may be an additional source of contamination. If the milking machines are washed and sterilized properly, all well and good; but often they are not properly cared for and are the direct cause of large numbers of bacteria in milk.

The ability of well-informed and careful dairymen to produce clean milk with milking machines is shown by the fact that certified milk is being produced with them. The same is true of market milk of good grade drawn with machines, under ordinary farm conditions. There is no short cut, however, to cleanliness; clean milk can not be obtained by using neglected machines. To attain this objective, machines must be thoroughly and regularly washed and sterilized.

The Department of Agriculture is conducting investigations in the cleaning of milking machines, and from the experience gained so far it advocates a method of cleaning which is simple and effective in producing milk uniformly low in numbers of bacteria.

POINTS WHICH REQUIRE CAREFUL ATTENTION.

Owing to the construction of milking machines, persistent care must be exercised in cleaning them. Each of the following points requires careful attention:

Rubber tubing, including glass unions.
Teat cups and inflations.
Claws.
Pail.
Head.
Valves.
Moisture traps.
Vacuum lines.

Definite cleaning instructions should be followed by each milking-machine user.

HEAT STERILIZATION FOR MILKING MACHINES.

The heat method of sterilizing milking machines, which is presented in this bulletin, was tried on a number of farms and proved successful. Its effectiveness is shown by the following results obtained on samples of machine-drawn milk at farms where this method was used.

Samples taken at 13 farms using various methods other than heat for the purpose of sterilizing the machines had an average bacterial count of 257,900 per cubic centimeter for 74 samples.[1] Samples taken at the same farms when the heat method of sterilizing the machines was used had an average bacterial count of 19,300 per cubic centimeter for 261 samples.

Samples of machine-drawn milk taken at a total of 20 farms using this method for sterilizing the machines had an average bacterial count of 13,750 per cubic centimeter for 622 samples, and 376 of the samples had a count of 10,000 per cubic centimeter or less.

The effectiveness of heat sterilization for cleaning milking machines on some representative individual farms is shown in the following table:

TABLE 1.—*Effectiveness of heat-sterilization method of cleaning milking machines.*

Farm No.	Number of samples.	Period covered.	Average bacterial count per cubic centimeter.	Farm No.	Number of samples.	Period covered.	Average bacterial count per cubic centimeter.
1	188	2 years	12,700	4	79	4 months	11,500
2	31	2 months	23,100	5	45	2 months	5,100
3	45	3 weeks	17,400	6	74	5 months	5,600

Bacterial counts obtained on comparative tests made with machines sterilized by this method, and others sterilized in a chlorinated-lime solution, were in favor of the heat method for sterilizing.

All bacterial counts are of samples taken under actual farm conditions direct from the machine pail. All machines were handled entirely by the owner or his employees according to a set of directions left with them. The average age of samples when count was made was about 12 hours. Standard methods were used in making the bacteriological analyses.

EFFECT OF HEAT ON THE RUBBER PARTS.

The effect of heat on the rubber parts has not yet been fully determined by this department. So far, however, the temperatures used (160° to 170° F.) have been but slightly if any more detrimental to the life of the rubber than other methods of sterilization.

Some users have obtained as long as 17 weeks' wear out of the teat-cup liners when using this method, while others have obtained only 6 weeks' service. This variation can be attributed to four things:

1. The grade of rubber used in making the liners.
2. The number of cows milked with a set of rubbers.
3. The condition of rubbers when discarded.
4. Care and cleanliness of rubbers.

1. The life of the rubber liners and mouthpieces varies considerably under exactly the same care and use, due undoubtedly to the difference in grade of rubber.

2. The number of cows milked with the machine and the number of milkings each day also affect the life of the rubber. The oftener the teat-cup rubbers are used, the sooner they wear out.

---

[1] The term "bacterial count" means the number of bacteria found in a specified quantity of milk, usually a cubic centimeter. A cubic centimeter equals about 16 drops

3. There is a great difference in the degree of wear at which the rubbers are discarded by various operators. Some operators replace rubber parts that are still in good enough condition to last several weeks. These operators are usually those who have large numbers of cows to milk. They say that the time saved in milking by replacing rubbers frequently more than pays them for the additional expense of new rubbers. In no case, however, should old, cracked, or split rubbers be used.

4. It is necessary that the rubbers be thoroughly cleaned before sterilizing, as butterfat has a deleterious effect on them at temperatures used for sterilizing and shortens their life materially.

The temperatures recommended have no apparent effect on the length of life of the short or the long rubber tubing.

HOW TO CLEAN AND STERILIZE MILKING MACHINES, TOLD IN PICTURES.

Steps in the care and use of milking machines are portrayed in the accompanying pictures (Figures 1 to 13).

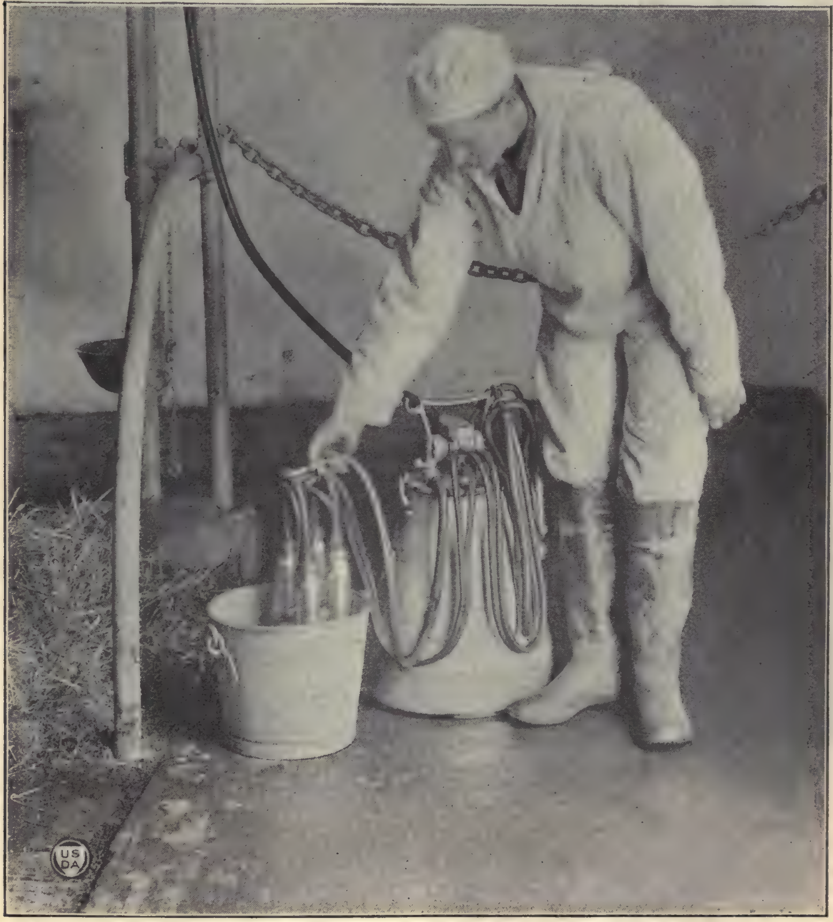

FIG. 1.—Immediately after milking, the machines are rinsed with cold or lukewarm water drawn through the machines by vacuum. The flow should be broken occasionally by pulling the teat cups out of the water and then immediately immersing them again. This is done 10 or 12 times.

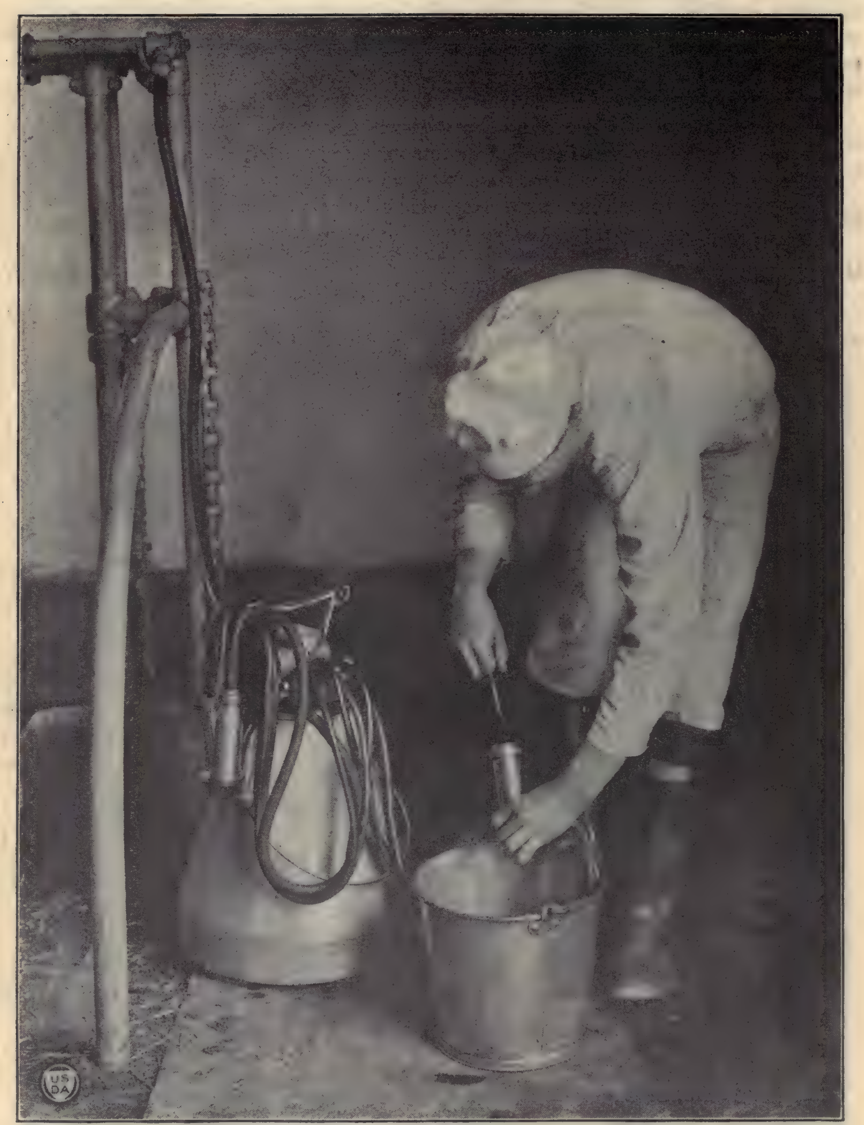

FIG. 2.—Repeat the rinsing process, using hot water containing washing powder. Teat cups and tubing are washed with a brush at this time.

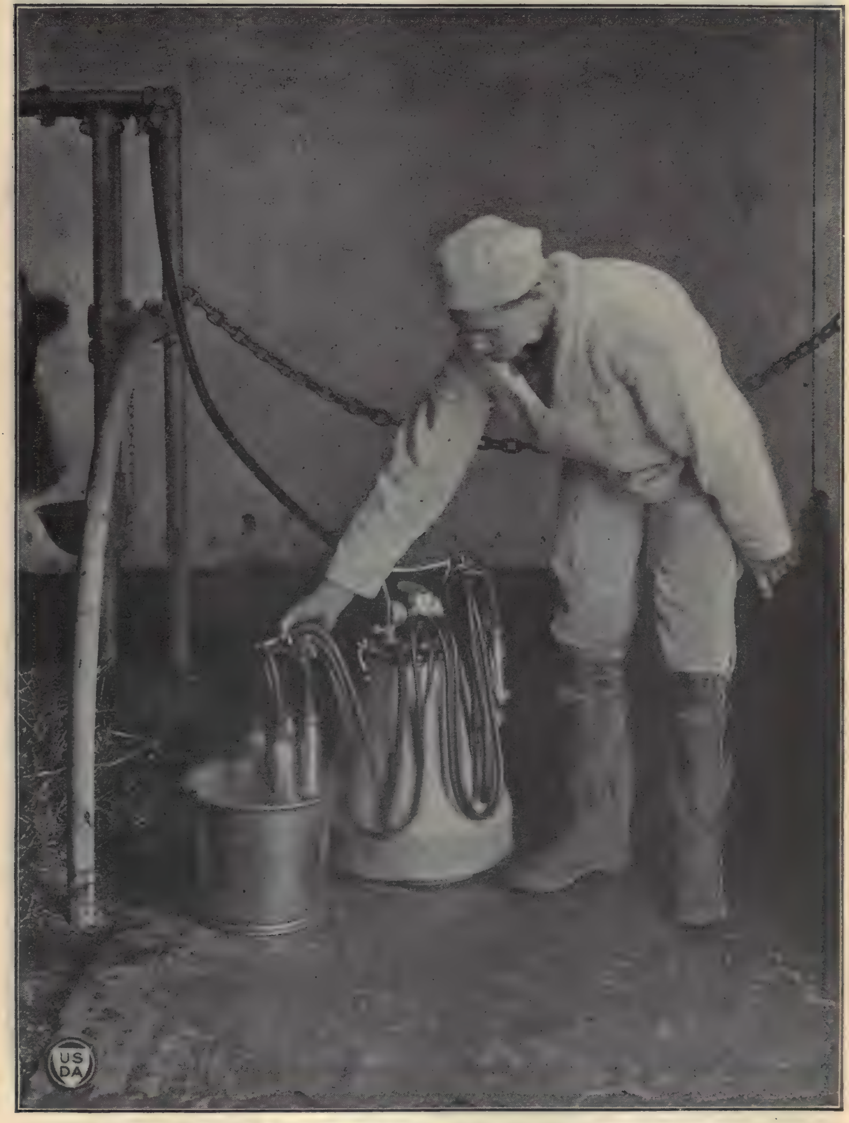

FIG. 3.—Then rinse the machines with clean water drawn through by vacuum.

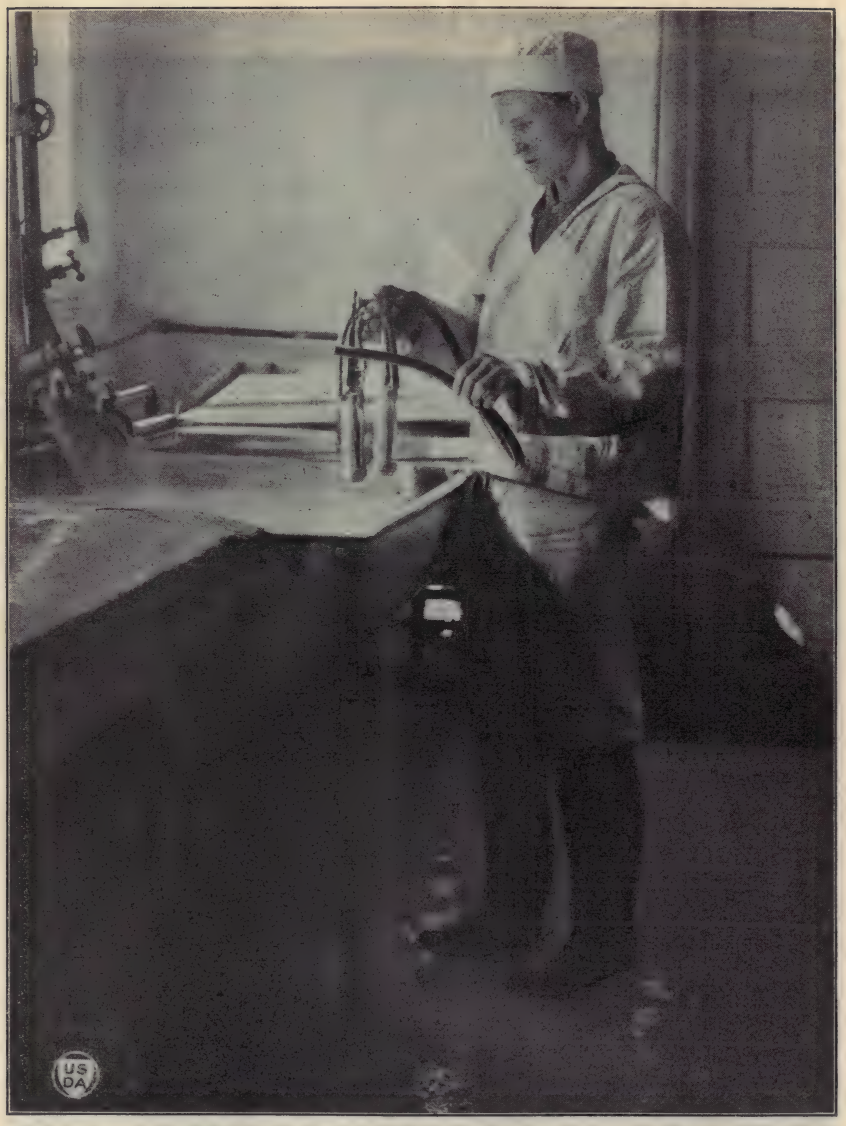

FIG. 4.—The long milk tube with claw and teat cups is then detached from the head of the pail. Air tubes (on machines of inflation type) are plugged, and the whole is placed in a tank or a can of clean water, care being taken that all parts are entirely submerged.

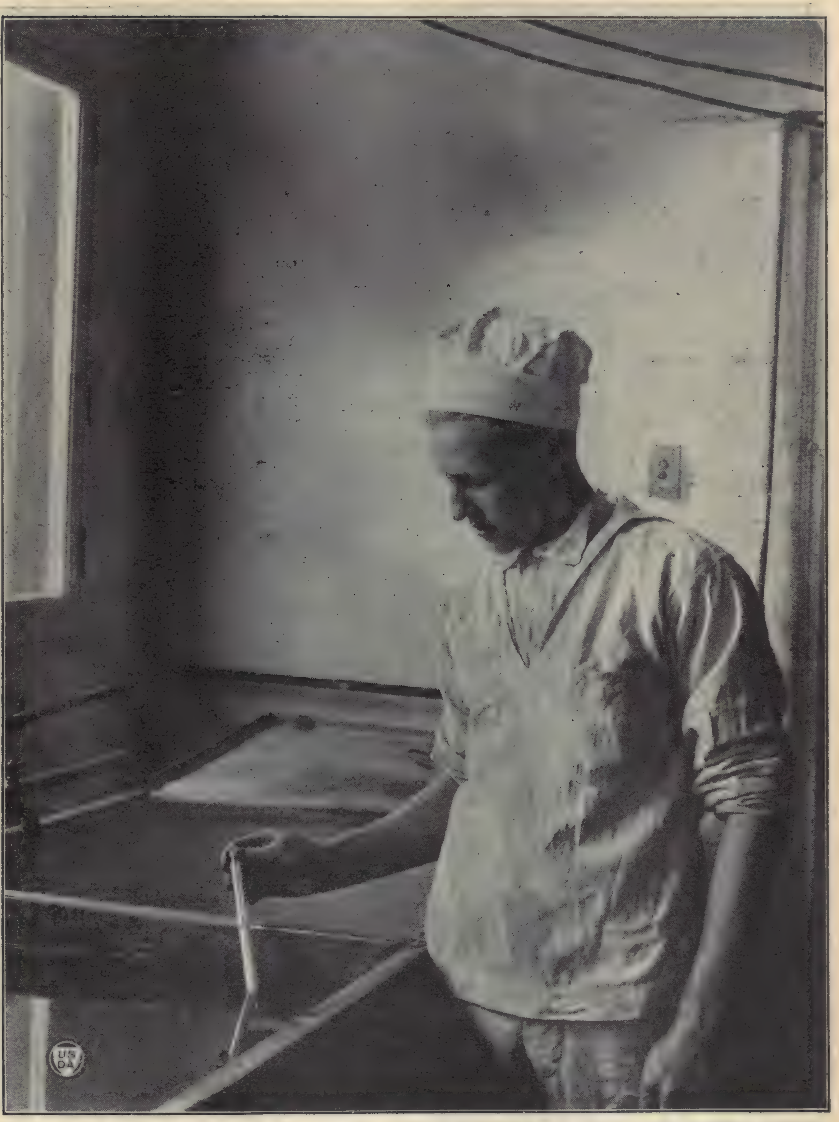

FIG. 5.—The water is then heated, preferably with steam, to a temperature of from 160° to 170° F. and held there from 15 to 30 minutes. The water is then allowed to cool and the parts to remain there until the next milking. A covered tank will usually hold the temperature above 160° F. for the required length of time, if heated to 165° or 170° F.

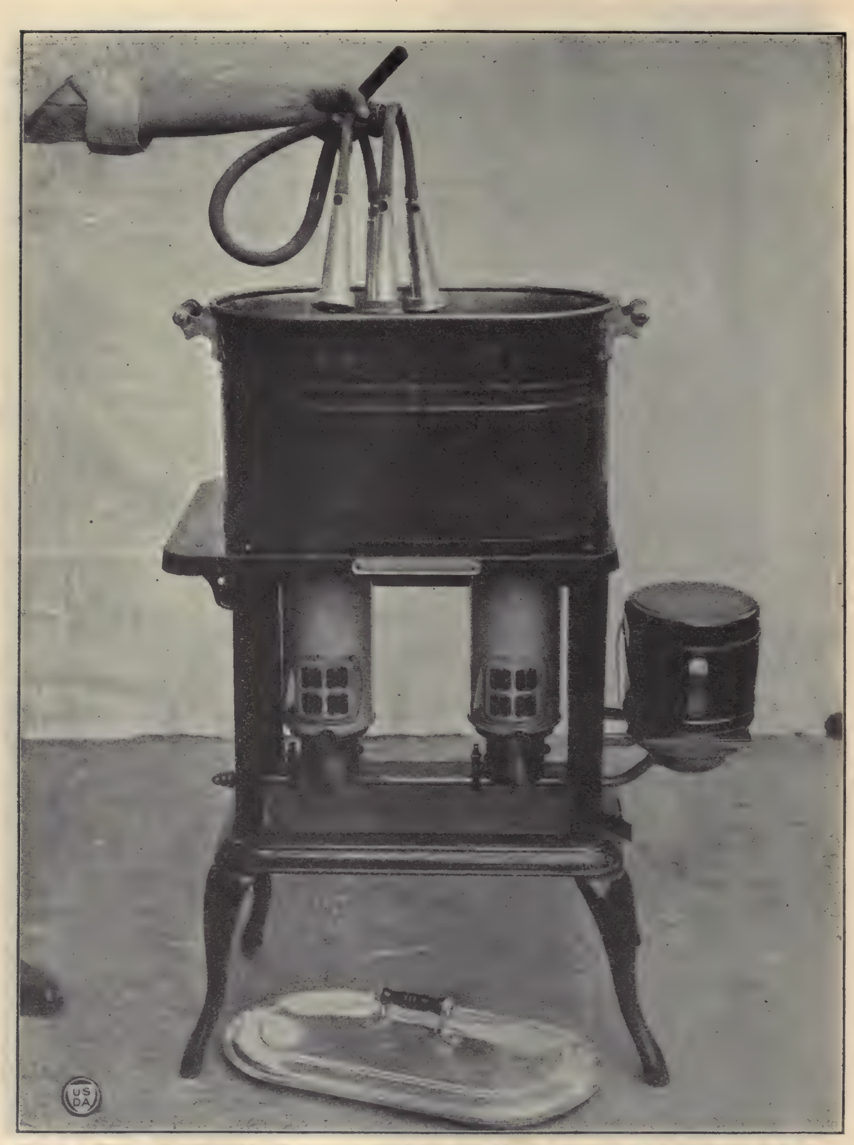

FIG. 6.—Where steam is not available for heating, the water may be heated in a wash boiler on a stove. If the water is so heated, it is best not to place the rubber parts in the water until the proper temperature has been reached and the boiler removed from the stove; otherwise the rubber parts may be injured by coming into too close contact with the heating medium.

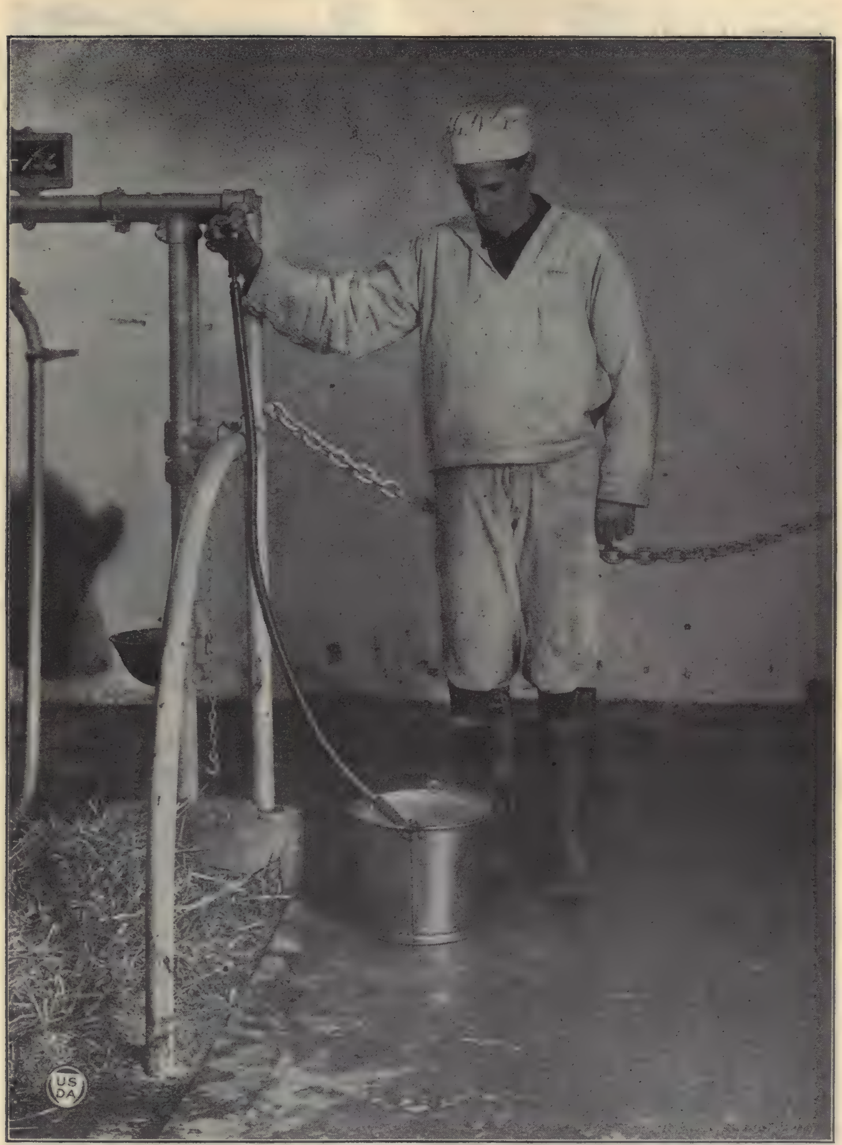

FIG. 7.—The vacuum line should be cleaned about every two weeks by drawing hot water, containing washing powder, through it with vacuum. If milk is drawn into the vacuum line, the pipe should be cleaned immediately after milking.

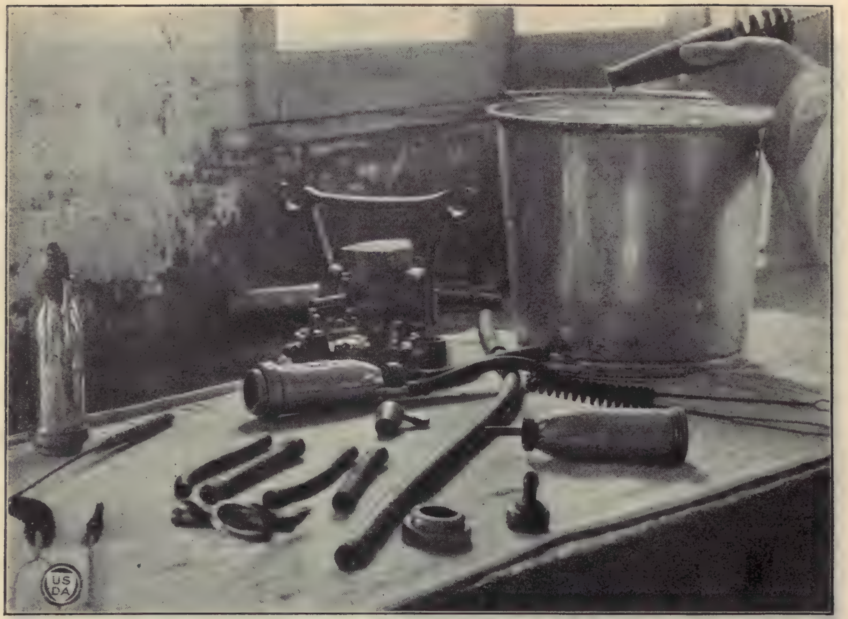

FIG. 8.—Twice each week the machines should be taken entirely apart and washed thoroughly with brushes and hot water containing washing powder.

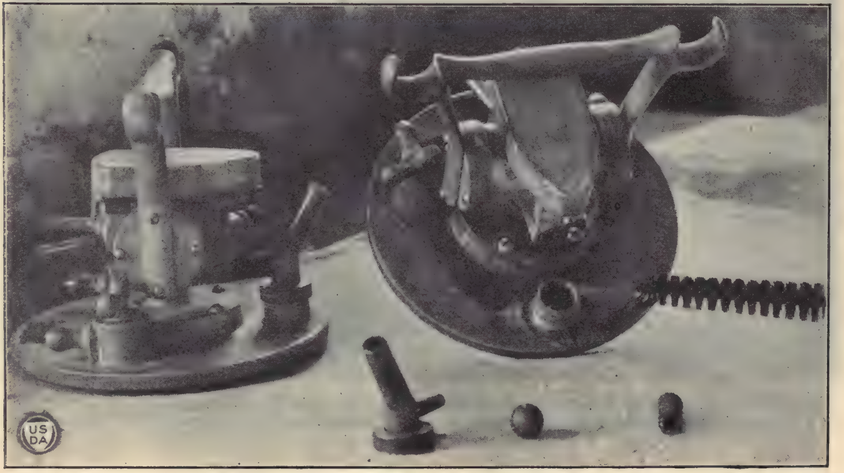

FIG. 9.—The moisture trap or check valve on the head of the machine (cover of pail) should be cleaned every day.

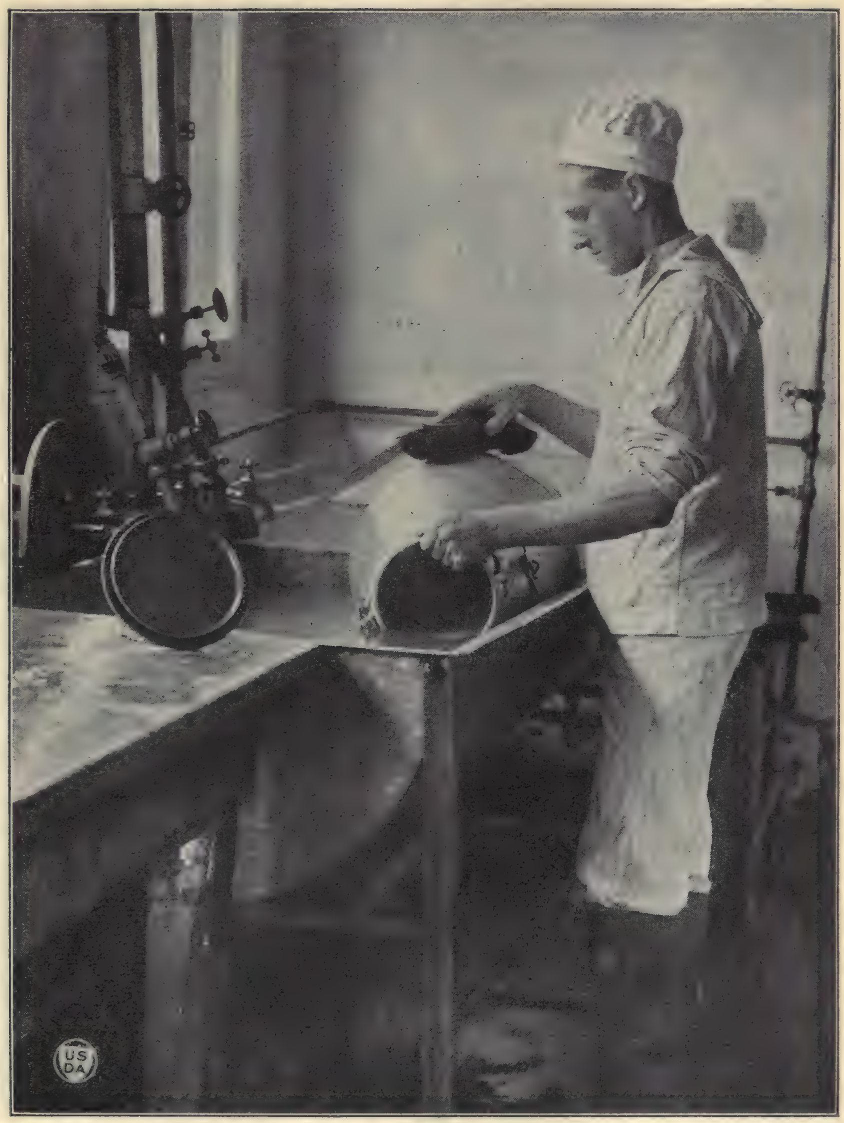

FIG. 10.—Milking-machine pails and covers should be thoroughly washed after every milking and then sterilized.

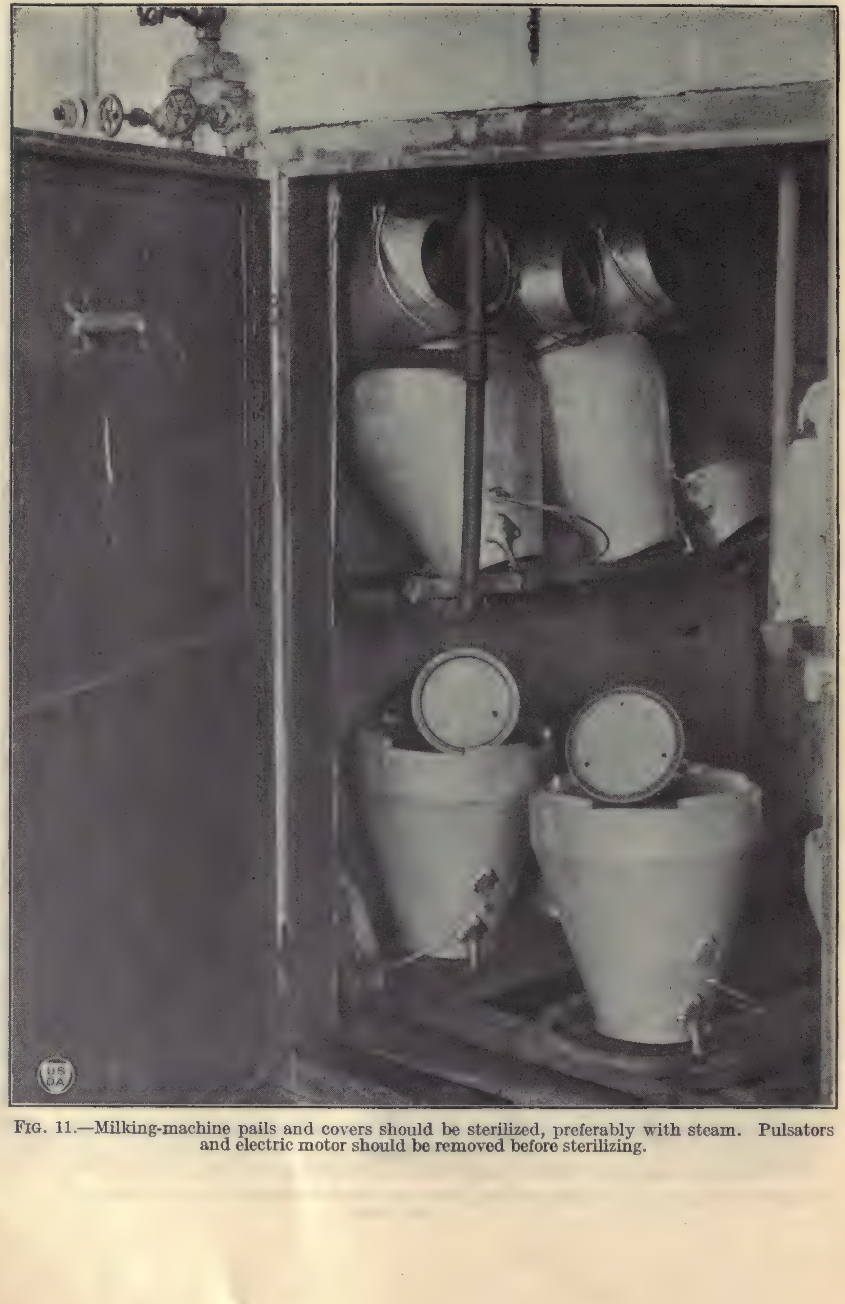

FIG. 11.—Milking-machine pails and covers should be sterilized, preferably with steam. Pulsators and electric motor should be removed before sterilizing.

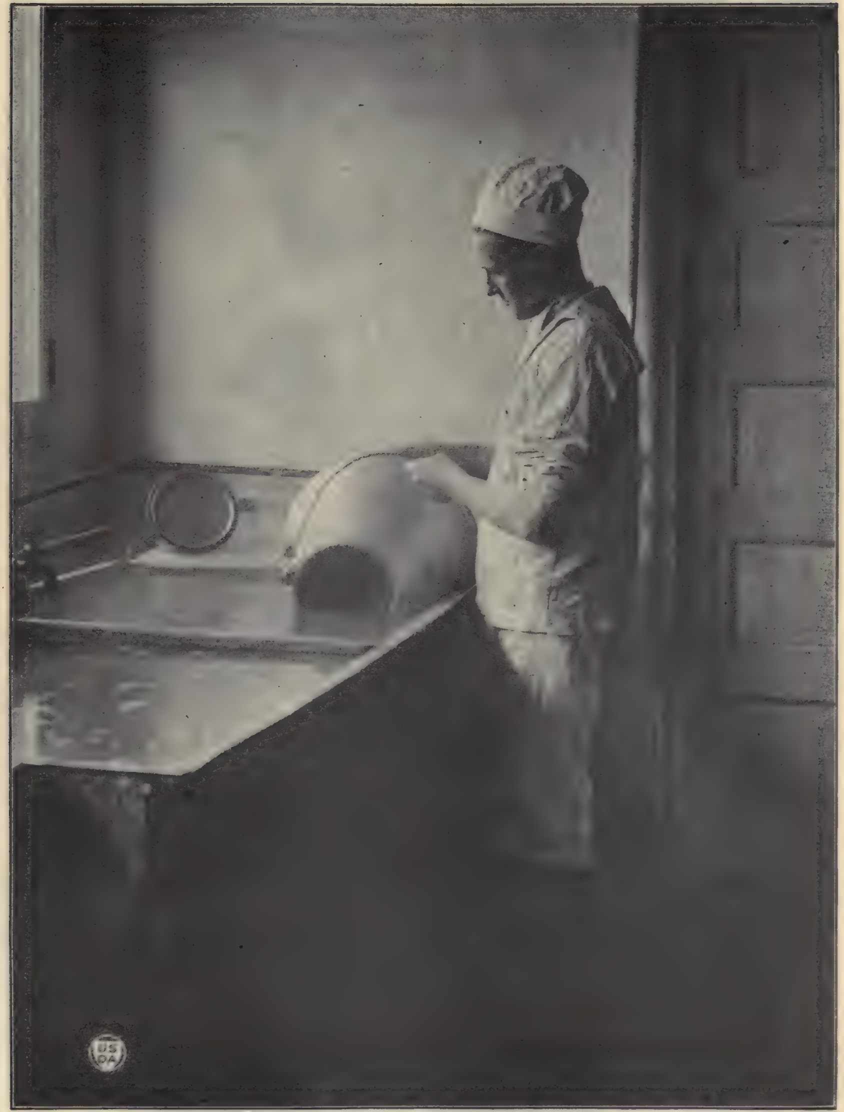

FIG. 12.—If steam is not available, the covers and pails should be sterilized by immersing in boiling water for 5 minutes.

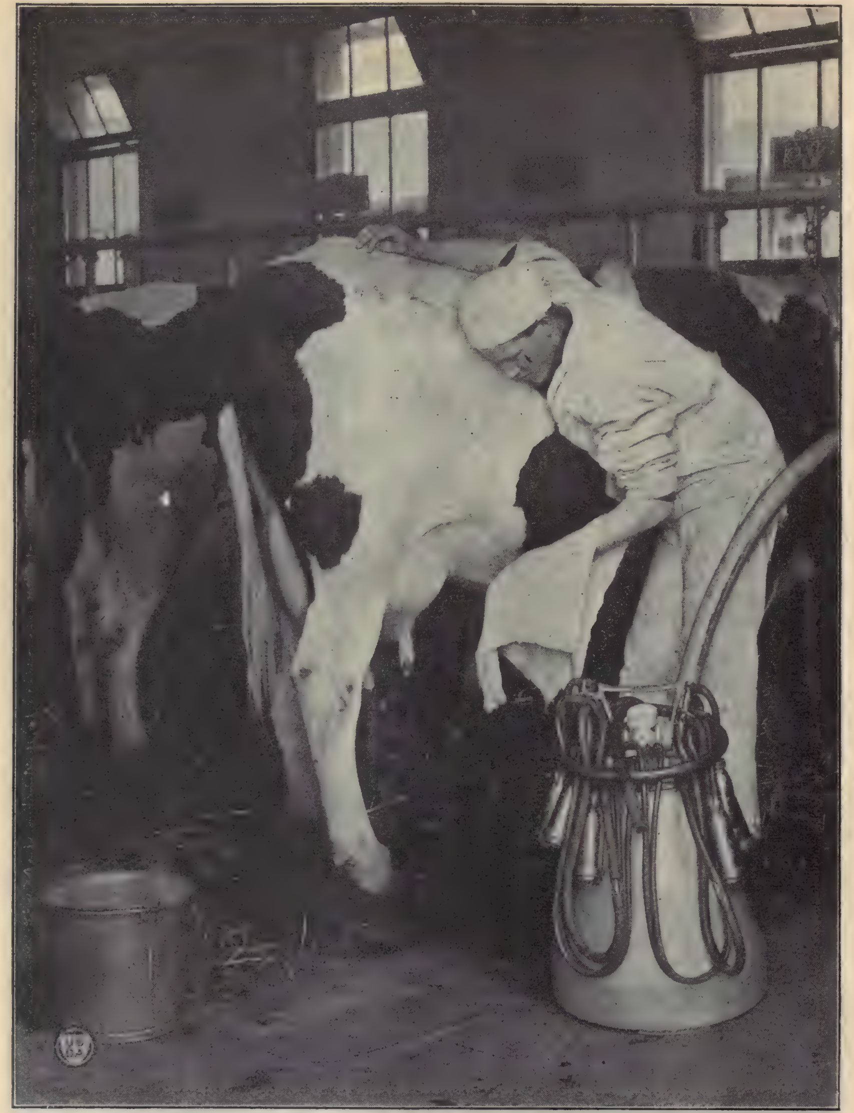

FIG. 13.—The cleaned machine is assembled ready for use. Before beginning milking, the udder and flanks of the cow should be cleaned by wiping with a clean, damp cloth.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1316

MARKETING THE EARLY-POTATO CROP

THE EARLY-POTATO CROP must be grown quickly, harvested promptly, and sold at once.

The special market problems are those of the truck grower rather than of the general farmer. A good return to the producer depends upon reaching the market early or when it is comparatively free from other potato supplies.

The crop requires special methods of handling, grading, packing, loading, transportation, and distribution. Everything must be done promptly and well, hence the need of the best and most competent business methods.

Markets for such crops change rapidly and they vary from season to season. The grower should keep in close touch with crop news, shipment reports, and market quotations.

The market season for any early potato district lasts only a few weeks. Into that short time must be condensed the net results of the season's work and planning.

This bulletin tells how the crop is sold in the leading early-potato sections; the location, shipping points, and relative importance of the heavy early shipping districts are shown; kind and source of information which the grower should use are described; and the grower told how to make the most of them in marketing his crop.

Washington, D. C. Issued May, 1923

MARKETING THE EARLY-POTATO CROP.

GEORGE B. FISKE, *Investigator in Marketing Fruits and Vegetables*, and PAUL FROEHLICH, *Assistant in Market Surveys, Bureau of Agricultural Economics.*

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SELLING the early commercial potato crop is almost a business in itself. There are large districts in which early potatoes are the chief money product. The farmers depend on potatoes for their cash income; merchants sell fertilizer, tools, seed stock, and general supplies; and dealers trade in the product, and with the bankers, advance money to the growers. The railroads rely greatly on the freight from the outgoing shipments and the incoming supplies. Times are good or bad and money is plentiful or scarce in the district according to the returns received from early potatoes.

In the large cities there is a class of dealers and brokers whose spring and summer specialty is the sale of the early crop. Some of them handle a few later potatoes but have adopted the quick distribution methods necessary for the early crop. They have shippers who depend upon them for a prompt, reliable market outlet and customers who look to them for a sure source of supply of certain lines of early stock, year after year. The early potato arrivals are the leading feature at some city railroad freight yards during late spring and early summer. The railroads make special provisions for the supply of suitable cars and for quick transportation with prompt handling at the city end. Sometimes they list the growers and shippers at their various shipping points, with information on acreage planted, thus affording a guide to buyers.

EARLY-CROP REGION.

The border line between the early and late-crop sections can not be drawn exactly. Even the northern potato sections have an earlier crop consisting of quick-growing varieties planted in light soils and maturing a month or so in advance of the main crop. While these earlier crops of the North are sold chiefly in local markets, they meet some of the same problems as the early crops of the South. Strictly, the early crop includes all potatoes of the early varieties wherever grown, but commercially the early-crop regions are those in which the greater part of market crop consists of early, quickly-growing varieties not usually held in storage for later use, but sold promptly.

In some northern sections like New Jersey, Long Island, southern Idaho, and even Minnesota and Maine, the early crop is of commercial importance and is shipped to distant markets, but in general the border line of the early-crop sections passes through northern New Jersey and Long Island and westward to Missouri and Kansas. In these border regions are sections both early and late, which not only ship heavily in late summer but often hold large crops for winter sale.

Early-potato districts are found in 18 States. In most seasons the early crop is the principal commercial feature in these States although several of them ship both early and main crops. The 18 States are Alabama, Arizona, Arkansas, Delaware, Florida, Georgia Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, North Carolina, Oklahoma, South Carolina, Texas, and Virginia.

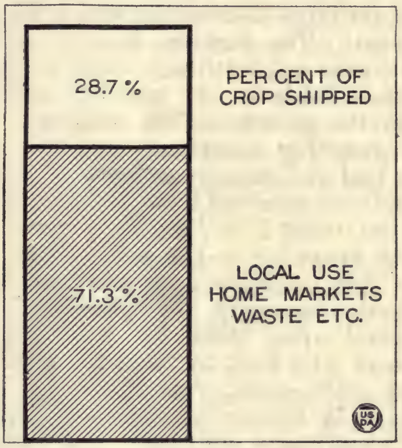

FIG. 1.—Disposal of the potato crop of the early-shipping States, five years, 1917-1921.

By no means are all the potatoes grown in the early-potato States shipped to distant markets. As shown in Figure 1, the early shipments average less than one-third of the estimated production of these States and are mainly from a few well-defined commercial areas indicated on the map in Figure 2. Later crops are grown rather generally throughout this region for home use and local markets. The relative importance of the early shipping States, as indicated by average carlot shipments, is shown in Figure 3. Figure 4 shows the average duration and volume of the movement from each section as the shipping season advances northward. In Figure 5 is shown the percentage and number of shipments of the crop of each State before September 1, which in most States would include practically all the early crop. The figures are based on average shipments from 1917 to 1921, inclusive.

Table 1 shows the main features of 10 important early-shipping areas in this group of States and the early districts of California and New York.

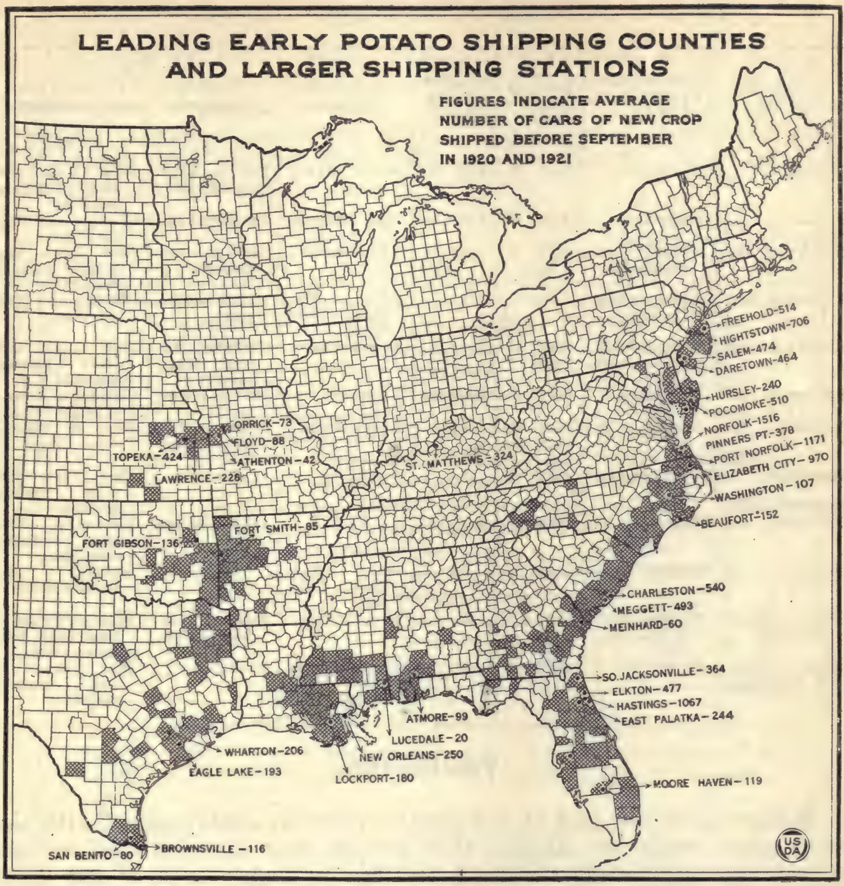

FIG. 2.—Bulk of early movement is from Gulf and Atlantic Coast regions.

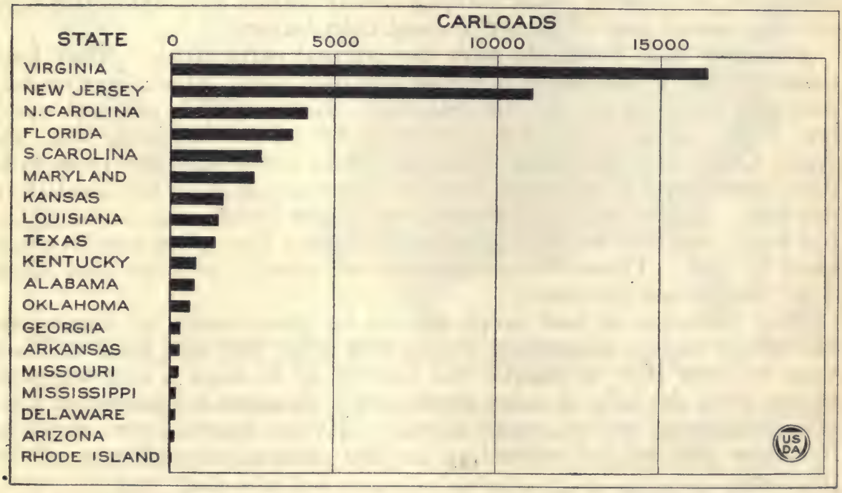

FIG. 3.—Comparative total movement from 19 early-shipping States. Five-year average, 1917–1921.

TABLE 1.—*Outline of prominent early-potato shipping districts.*

State or District.	Representative shipping center.	Season opens as early as—	Principal season closes—	Principal varieties.	Principal packages.	Principal consuming territory.
Florida	Hastings	Mar. 25	May 20	Spaulding Rose.	Double-headed barrels.	New York and other eastern markets.
Texas	Eagle Lake	Apr. 15	June 10	Bliss Triumph	100-pound sack	Chicago and Middle West.
South Carolina.	Meggett and Charleston.	May 1	June 15	Irish Cobbler	Cloth top slat barrels.	New York and other eastern markets.
Louisiana	Alexandria, Lockport.	do	do	Bliss Triumph, Burbank.	90–120-pound sacks.	Chicago and Middle West.
North Carolina.	Washington, Elizabeth City.	May 15 June 1	do	Irish Cobbler	Cloth top, slat, and stave barrels.	New York and other eastern markets.
California	Los Angeles	May 15	Aug. 31	Burbank	116–120-pound sacks.	California and Western States.
Virginia	Norfolk, Onley.	May 25 June 1	do	Irish Cobbler	Cloth top stave barrels.	East of Mississippi River.
Maryland	Pocomoke City.	June 15	do	do	do	New York and other eastern markets.
Kentucky	Louisville	June 25	Sept. 30	do	120-pound sack	Kentucky, Illinois, Indiana, and Ohio.
Kansas	Kansas City	July 1	do	Early Ohio, Irish Cobbler.	do	Missouri and Middle West.
New Jersey (South).	Woodstown, Hammonton.	do	do	Irish Cobbler	Bulk and 150-pound sack.	Pennsylvania, New York, New Jersey, Ohio.
Long Island, N. Y.	Riverhead	July 15	do	Green Mountain, Irish Cobbler.	Bulk	New York City and eastern markets.

VARIETIES.

While the selling end of the potato question deals mainly with the crop when ready for market, it is well to bear in mind that success in marketing depends much on having the right stock at the right time. The variety should be one that is marketed in large quantities from the locality, thus making sure of carlot shipments throughout the season and of plenty of local cash buyers.

Potatoes from Bermuda were the original early stock. They happened to be a well-known, small, reddish sort, which was widely adopted by growers in the Southern States. This original stock has been replaced to some extent by pink varieties, like the Early Ohio and Spaulding Rose, or white kinds like the Irish Cobbler, considered more productive or better adapted to the locality or market. In the early-potato sections of the North, also, some of the old kinds are now so little grown for market that pure seed stock is hard to find. These changes were made slowly, and the new kinds were first tested cautiously.

New varieties or new crops should be grown only by those who can afford to lose something in the first trial, but who hope to learn year by year how to handle the variety or to start a new shipping center with the help of other producers. Changes in amount or kind are dangerous unless made slowly. Every season new shipping localities rise or fall according to the caution or rashness of the planters.

PLANNING AHEAD.

Planting begins in some early-potato sections about January 1, long before anyone knows just what the market will do with the remainder of the main crop. Growers must make their plans four months ahead of marketing time. The practical question is whether the main crop will be out of the way by the time the new crop is ready to take its place.

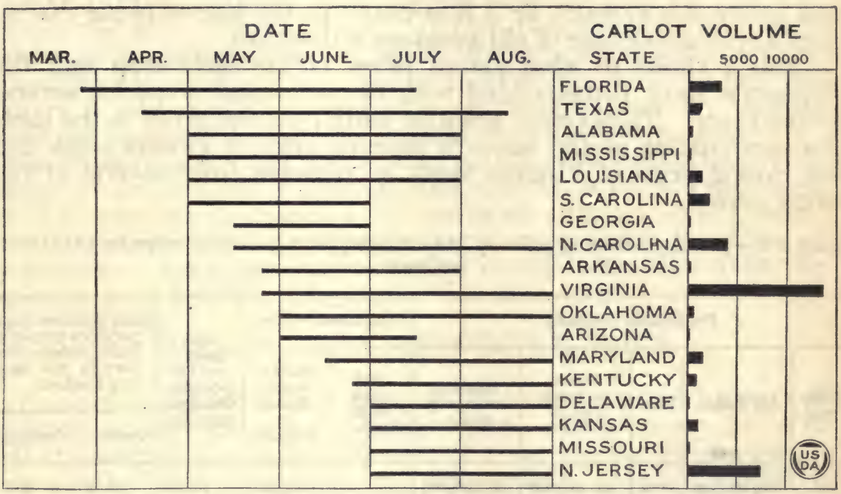

FIG. 4.—Early carlot movement from early-potato sections 1920–1921.

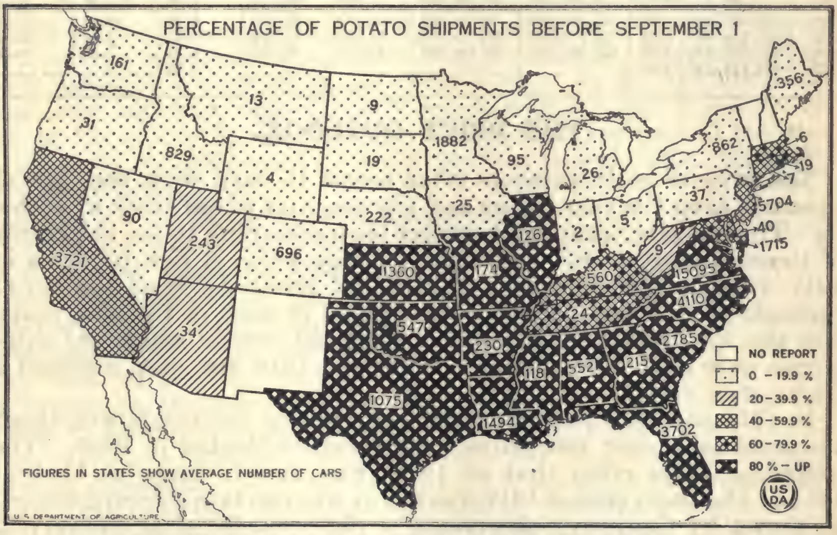

FIG. 5.—The Southeastern area supplies four-fifths of the early shipments.

The chief points that can be considered so early in the season are the size of the main crop, the amount shipped, the length of the shipping period, and the price tendency. Was the crop more than average or less, and was the shortage or surplus located in the consuming States or in the shipping regions? In general, when the figures show that the estimated total main crop is well below average and much of the shortage is in the late-shipping States along the northern border of the country, the shipments will dwindle rapidly during the late winter and spring. In such seasons the price tends to advance as long as old stock continues in good condition. New stock tends to open at high prices and to remain rather high unless the supplies from competing early sections are very large and shipments increase too fast. If, on the other hand, the estimated main crop is well above the average, or if it is heavy in the late-shipping States, then a spring shortage of old potatoes is doubtful.

Table 2 shows to what extent prices of the early crop and the shipments have corresponded with the estimated crops for several recent years. The average price for early potatoes given in the table is a combination of the season's opening price of Florida stock and the closing price of Virginia stock as reported from several of the larger cities.

TABLE 2.—*Correspondence of prices of the early crop with estimated crops for 1915–1922, inclusive.*

Crop year.	Production—bushels.				Shipments—cars.		Old stocks per 100 pounds, Chicago, January.	Early potatoes, comparative price per barrel, sales to jobbers in the large city markets.	
	All States.	Year.	Stock on hand Jan. 1. 35 States.	Leading early-crop States.	Old stock after Jan. 1.	Early stock, March to August.		Average.	Opening.
1915..	359,721,000	1916	84,433,000	62,430,000	....	44,061	$1.75	$3.96	$6.75
1916..	286,958,000	1917	54,860,000	80,297,000	35,043	44,010	2.96	6.33	11.50
1917..	442,108,000	1918	108,778,000	73,905,000	51,876	37,604	2.12	5.96	8.50
1918..	411,860,000	1919	93,258,000	63,206,000	58,240	29,813	1.91	8.28	12.00
1919..	322,867,000	1920	65,405,000	78,556,000	60,884	39,502	4.28	10.50	17.50
1920..	403,296,000	1921	90,023,000	61,203,000	61,498	43,564	1.30	6.50	11.25
1921..	361,659,000	1922	125,290,000	79,714,000	82,434	54,737	1.94	7.50	11.00
1922..	451,185,000	1923	....	....	....	....	.83	....	....

THE PRICE OUTLOOK.

The price of early potatoes often seems to vary with the size of the main crop the year before and the quantity of old stock available for shipment after January 1, rather than according to the shipments of the new early crop. Thus the average price of new potatoes in 1917 was nearly double that of 1916, yet about the same number of carloads of new early stock were shipped in each of the two years. But the 1917 new crop followed a short old crop of which the shipments were light after January, while the 1916 new crop followed a heavy main crop.

In 1918 and 1920 the volume of early-potato shipments was about the same each year, but prices were decidedly higher in 1920. The preceding main crop, that of 1919, was not so large as that of 1917. The main crop of 1919 was heavy in some late shipping States, as shown by the heavy shipments of old potatoes after January 1. Hence the report of stock on hand January 1 is, to some extent, a revision of the crop reports and should be noted in detail as well as the estimate of the main crop. The effect of a large winter supply of old potatoes is shown not only in the heavy carlot supplies following but also in the poor demand because of the local small-lot supplies near the towns and cities.

Again in 1920 and 1921 there were nearly equal shipments of new potatoes each year, and the far lower prices of 1921 must be explained in part by the heavy main crop of the preceding year. In the seasons 1917 to 1921, inclusive, the war-time inflation and the general price slump following greatly affected the price action, but did not control, except perhaps in 1919, when the average price of new potatoes was high, notwithstanding the comparatively large main crop of 1918. Here again the moderate volume of old stock moving after January 1, 1919, indicated that the surplus of the crop was not very large in the late-shipping States. It may be concluded that while the size of the estimated main crop is often a good indication of the outlook for the following early-potato market, yet the stock on hand January 1 also should be taken into account; likewise any special conditions that might affect the natural course of the markets.

The official estimate of marketable potato stocks on hand, issued usually toward the end of January and sometimes revised in March, makes it possible to judge of the probable supplies of old stock. According to the six-year average record used, about two-fifths of the January 1 stock goes to market in carlots after that date, the rest being used locally or disposed of in other ways.

FORECAST FROM MIDWINTER PRICE.

The price of old potatoes in January is often a general forecast of the prices of the following new early crop. The January price in itself expresses the condensed opinion of buyers and sellers regarding the stock on hand, the supply, and the demand. During the seven years, 1916–1922, the opening price of Florida potatoes was usually three to four times the average January price of old stock per 100 pounds in the Chicago carlot market. Except in 1919, the high or low opening price of new potatoes was foreshadowed by comparatively high or low January prices of old stock. As the opening price sometimes indicates rather closely whether it is to be a season of high or low prices, it may be fairly stated that the prevailing January price of old potatoes is worth taking into account when planning for the early crop.

In two of the seven recent seasons considered in the table, all of the indications were strongly favorable to producers. In 1917, the preceding main crop had been very short. The January stock on hand was light and the price very high. Business conditions also were active. In 1920, the indications were again favorable in all these respects. In either year, the early planter may be said to have received the "go ahead" sign. In the years 1918 and 1921 conditions pointed strongly the other way, indicating the desirability of light planting. For the other three years of the series, 1916, 1919, and 1922, the indications were not very strongly marked in either direction. Of these years, 1916 was one of prevailing low prices, 1919 was high partly on account of war-time inflation, and 1922 was a season of medium prices. The conclusion is that the planter may safely increase his usual acreage only when all indications are plainly in favor of a strong market. When the signs are mixed or doubtful, the usual acreage should be planted.

WATCH THE OTHER POTATO CROPS.

The early crop usually sells high if the old crop is out of the way in time. Therefore, the grower in the early sections should study the market or crop situation carefully and plant according to the probable supply of old potatoes in the spring and early summer, as indicated by reports of northern production, shipments, stock on hand, and prices. In a general way a short main crop means a good demand for early potatoes and high prices unless the early crop is very large.

The early planter in Florida, Texas, or California should plant heavily or lightly according to the probable supply indicated by size of main crop and reported stocks on hand. As a matter of fact, many farmers plant according to the market success of their own crop the season before and often come forward with a large crop when the northern markets are full of cheap old stock. Especially risky is the common tendency of new growers to plant heavily in the years following a season of high prices. There is always a possibility that prices will be high several years in succession, but more often high prices are followed the next season by large supplies and small returns to the growers. Plans should be based not only on the past but on the probable future.

The grower must watch crop conditions in the districts which may compete with his own. Light planting or crop damage in earlier competing sections means greater demand for his own crop. On the other hand, large acreage and favorable weather in earlier sections point to caution in planting and perhaps to delay in harvesting until the high point of competing shipments has been passed. In the first case the crop may be dug when still a little green because of high prices to be had for early shipments. Extremely early shipment, however, seldom pays because of the lighter yield and the greater danger of loss by heat and bruising. Plainly, competing shipments must be watched not less than the total crop in order to enter the markets at the right time.

A SAMPLE SEASON.

In the season of 1920–21, for example, the grower in the far South might have noted in the official December crop reports that the yield was far above the average and the crop rather large in most of the States that ship heavily during the last part of the main-crop market season. He could have found that the shipments reported for the early months of the season, October to December, were not large in proportion to the crop, showing that heavy stocks would come upon the market later. Accordingly, if wise, he would plant lightly.

The potato grower in the sections from Virginia and the Carolinas westward could follow a similar course, especially on noting the report of oversupply in northern markets and the ample stocks on hand January 1. Sections north of Norfolk, Va., including the Virginia-Maryland Eastern Shore and southern New Jersey, the early sections of Minnesota and northern Idaho, and the Kaw Valley, none of which does much planting before March 1, would take into account not only the old main crop but also the acreage and the condition of the crops in earlier competing sections and their probable earliness or lateness.

The official report of the United States Department of Agriculture published early in April showed a decrease from 1920 of about 30,000 acres planted in nine early States, including about 10,000 acres decrease in Virginia, which is the most important second-early shipping section. The season was early for all crops, and the new potato crop would naturally enter the markets earlier than usual. This would leave an opening for the crop of New Jersey and other intermediate sections and for the planting of early varieties in the States farther north.

These conclusions worked out rather well. Early potatoes sold comparatively low in relation to cost of production, but no doubt would have been still lower had not the early acreage been reduced. The Northern early crop found a potato market only moderately supplied in August and September and sold at prices fairly satisfactory to growers, although yield was below the average.

In the 1921–22 season conditions were different in some ways. The main crop was short, as shown in the December official report, but production was large in several of the latest shipping States, which always ship heavily in proportion to yield. Shipments were unexpectedly heavy from some of the newer potato sections in the Northwest, especially from the Dakotas. Indications for the early planter were somewhat doubtful, and suggested only a moderate acreage. The large stock of old potatoes on hand January 1, followed by heavy shipments and declining prices, also suggested caution to late February planters. However, the crop was heavy in Florida and early shipments found a good market, partly because of the freezes in southern Texas, which is Florida's most important early competing section. Reports of increased acreage in most of the very early shipping sections, together with continued liberal supplies in Northern markets, suggested caution in the intermediate potato region.

The intermediate sections forecasted production somewhat larger than in 1921, but with little increase in New Jersey and a decrease in Virginia. This suggested that there might again be a good market for early potatoes in June, July, and August. Reports of slowly improving business conditions were also encouraging as indicating an increase of buying power on the part of the consuming public. Heavy planting of the main crop and a July 1 forecast of total crop far above the five-year average gave early indication of a coming season of liberal main-crop production.

LOOKING OVER THE MARKETS.

The selection of markets depends upon conditions of demand, supply, and price, which change continually. The shipper must learn these conditions by reading the market reports from day to day. On the whole, however, prices do not often vary greatly between principal city markets when the difference of 5 to 15 cents per 100 pounds in freight charge is taken into consideration. During seasons of prosperity, prices have ranged higher in Pittsburgh than in New York and Philadelphia. New York prices sometimes have ranged higher than Philadelphia, although freight rates are nearly the same. Early shipments have sometimes reached highest prices in the Boston market. Chicago has often quoted high prices for Eastern potatoes when there has been a shortage of supplies from the South Central early shipping sections. There are certain conditions which prevail year after year. Table 3 shows some of these more lasting conditions—the quantity, varieties, and sources of the early-potato supply in a number of the large markets. The condensed description should aid the shipper in selecting the natural market outlet for his carlot sales.

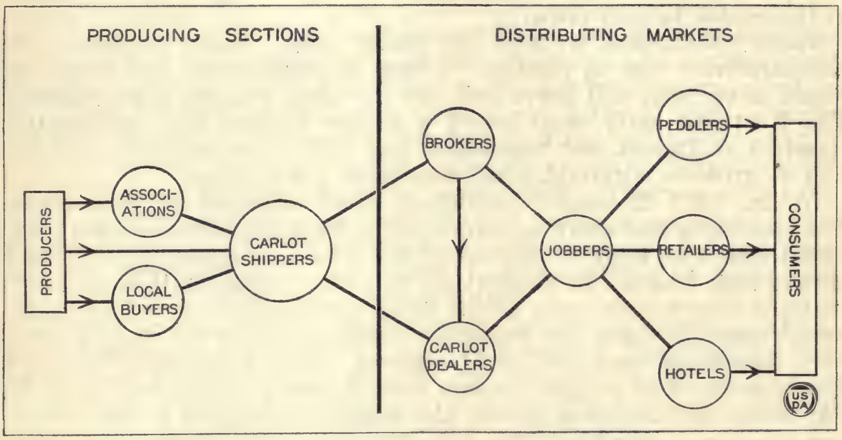

Fig. 6.—Usual market route of early-potato shipments.

Table 3.—*Early-potato supplies of 18 cities.*

City.	Annual carlot early-potato unloads, 5-year averages.	Origin of carlot early supply.	Per cent of yearly supply from early shipping sections.	Leading varieties early carlot receipts.
Baltimore	[1] 1,008	Florida, North Carolina, Virginia	40.5	Spaulding Rose, Cobbler.
Boston	[1] 1,777	Carolinas, Virginia, New Jersey	20.2	Do.
Buffalo	[1] 1,306	Florida, Virginia, New Jersey	55.3	Do.
Chicago	2,801	Florida, Texas, Louisiana, Virginia, New Jersey.	23.9	Do.
Cincinnati	645	Florida, North Carolina, Alabama, Virginia, New Jersey.	31.6	Triumph, Ohio, Spaulding Rose.
Cleveland	[1] 1,344	Florida, South Carolina, Virginia	42.9	Cobbler, Bliss Triumph.
Columbus	[1] 245	Florida, Virginia	30.2	Cobbler, Spaulding Rose.
Detroit	1,037	Florida, Virginia, New Jersey	41.3	Do.
Indianapolis	[1] 423	Virginia, Kentucky	26.0	Cobbler.
Kansas City	482	Texas, Louisiana, Oklahoma	19.97	Bliss Triumph, Early Ohio.
Minneapolis	66	Texas, Oklahoma	7.6	Bliss Triumph, Spaulding Rose.
New York	8,589	Bermuda, Florida, Carolinas, Virginia, New Jersey.	45.9	Cobbler.
Omaha	[1] 103	Texas, Kansas	9.9	Early Ohio.
Philadelphia	3,375	Florida, Carolinas, Virginia, New Jersey.	47.4	Spaulding Rose, Cobbler.
Pittsburgh	2,466	Florida, North Carolina, Virginia, New Jersey.	41.1	Do.
St. Louis	439	Texas, Louisiana	15.1	Bliss Triumph, Long White.
St. Paul	35	Texas, Oklahoma	10.2	Bliss Triumph, Spaulding Rose.
Washington	[1] 544	Florida, Carolinas, Virginia	53.8	Spaulding Rose, Cobbler.

[1] Less than 5 years. Boston figures include carlot reshipments.

MARKET INFORMATION.

Market news of country-wide scope is provided by the United States Department of Agriculture. Prices on sales of large quantities in leading markets, and country prices as reported by its representatives in shipping sections, are quoted daily. During the most active shipping season these reports are issued from branch offices in New York, Boston, Philadelphia, Baltimore, Washington, Pittsburgh, Cincinnati, Chicago, St. Louis, Kansas City, Los Angeles, and Minneapolis, and are mailed daily to thousands of potato shippers. Daily reports are also issued from several temporary field stations in large early-potato shipping districts, and are therefore within reach of most shippers. Facts regarding drought, storms, and freezes appear in the next official figures showing crop conditions or probable yield. Semimonthly crop notes issued by the Bureau of Agricultural Economics describe condition and progress of the crops in producing sections.

Weather, Crops and Markets, a weekly publication of the Department of Agriculture at Washington, includes much crop and market information of importance to growers and may be obtained at the subscription price of $1 a year, from the Superintendent of Documents, Washington, D. C.

Newspaper accounts are often unsafe guides because the early reports of drought, storms, freezes, and damage to crops are often far from accurate. Usually the real situation can be arrived at only after some time by comparing numerous local reports

A weekly review of market prices and conditions, issued Tuesday of each week, is available for free distribution from Washington or from the nearest market station. Brief summaries of market conditions are sent out daily from various points by means of wireless telegraph and telephone. Many local newspapers feature these various reports.

Various crop and market reports are issued by State departments of agriculture. Farm papers and produce-trade papers contribute additional crop and market news. Some county farm bureaus aid directly in potato marketing. The official reports of various kinds may be obtained free on application and should be kept in handy form where they can be used promptly for making plans for the crop and its sale.

Market information about the early crop is sent out from field stations of the Department of Agriculture at such central shipping points as Hastings, Fla., in April, and Charleston, S. C., Washington, N. C., and Elizabeth City, N. C., in May and June. Shipping-point news of the Eastern Shore of Maryland and Virginia and of southern New Jersey is issued from the Philadelphia market station and news of the Kaw Valley crop is sent out from the market station at Kansas City.

Among the publications of special interest to commercial potato growers are Farmers' Bulletin No. 753, Commercial Handling, Grading, and Marketing of Potatoes, and Farmers' Bulletin No. 1050, Handling and Loading Southern Potatoes.

Many of the railroad companies have an agricultural department which helps shippers in finding their market by publishing a list of buyers and shippers with the acreage and the amount of stock expected to be bought or sold. The local railway agent should be notified well in advance when the empty cars are to be needed for the movement of the crop.

The grower will also need the services of successful and reliable dealers. Information regarding the business standing and reliability of dealers usually can be obtained at the local banks and from various commercial directories. The dealer himself is often asked and should be willing to supply references as to his own financial position and reliability.[1]

FOR LOCAL MARKETS.

Although the early potato is chiefly a money crop, it is not all shipped to the great market centers. Growers living near towns and cities often find a convenient cash market for limited quantities. The grower of less than a carload (about 500 bushels) can not ship at carlot rates. In many northern and intermediate districts the early crop surplus is sold in small lots in markets within teaming and trucking distance. The buyers are grocery and provision stores, hotels, boarding houses, and families.

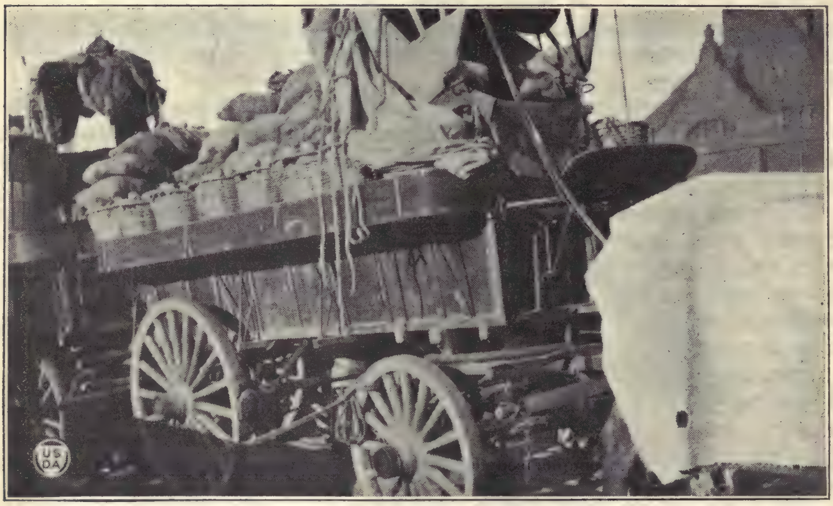

FIG. 7.—Bushel baskets are often used in local markets.

The requirements of this local trade in small lots are usually less exacting than for sales in distant large markets. The consumer cares less about the grading of his first lot of new potatoes than he does when storing his winter supply. The local trade demands chiefly that early potatoes be clean and of fair, usable size. The smallest must be picked out of the market grade, but can be sold at about half price to some restaurants and lunch stands, or even to family trade willing to buy small potatoes cheap.

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[1] The National League of Commission Merchants of the United States, with headquarters in the Munsey Building, Washington, D. C., is composed of some 650 produce dealers located mainly in the large market centers east of the Missouri River. It has requirements for membership as to financial standing, conduct, and personal integrity as well as a system of arbitration for the adjustment of disputes.

In the early local trade almost any variety can be sold. Sometimes a pink kind will sell better to certain classes of trade and sometimes the white varieties are asked for, but the color prejudice regarding the early supply is seldom strong in such markets. Earliness is of first importance. The small markets often have no early supplies shipped in from a distance, and the demand for the first new potatoes is keen for a short time. Then the price drops to about the usual range for the late crop, and gradually merges into the late market as the main crop varieties become abundant.

To dig at the most profitable time, in accord with these market conditions, requires judgment and experience. Beyond a certain point, the larger yield obtained at full ripeness will more than offset a somewhat lower price prevailing at that time.

Producers for local markets seldom use much machinery in harvesting. The potatoes grown on small farms for local market are dug with hooks or forks, throwing two or more rows in one furrow. The digging should be done in a dry time when the potatoes will shake out free of soil. For nearby marketing, the standard package is the box, which should be the regular market size and shape common in the vicinity. With the aid of wagon racks made for the purpose, the full boxes or baskets may be piled high on the wagon or truck without bruising the potatoes. High loads should be roped on firmly.

Sales in quantity can be made to army posts and naval stations according to conditions which vary from time to time, but which may be learned by addressing the Office of the Quartermaster General, and the Navy Bureau of Supplies and Accounts, at Washington, D. C. Army and Navy supplies are subject to official inspection. The grade, weight, and condition must be strictly up to requirements. Defective potatoes will be thrown out and deductions made for any shortage in weight.

FOR DISTANT MARKETS.

Most of the very early commercial crop is grown in rather thinly populated regions and must be shipped to distant consuming markets. When cash buyers are scarce or not satisfactory the crop may be offered to city dealers known to handle early potatoes. The shipper should find out about the firm long before the crop is ready and he should write to the dealer as soon as he can describe the probable quality, amount, and time of shipment of his crop. Many letters to dealers are too general in their description. A very large buyer must know how many carlots he can get at the shipping point, when they will be ready for shipment, what varieties, and whether graded or not. With such facts at hand, the dealer may be willing to look over the situation. Even if the shipment is to be sent forward for selling on commission, a description should be sent to the commission dealer so that he can arrange for its sale before it arrives.

The shipper may offer the potatoes to the dealer at a definite price. If he does, and the dealer accepts, it is a legal transaction whichever way the market goes, but if the shipper's offer is made "subject to confirmation" he need not sell unless he writes or telegraphs acceptance or a confirmation. If the car is to be handled by a broker, the same kind of notice should be sent to him. If the grower wishes to reserve the final word regarding a sale, he should add to the broker's letter, "Sale subject to confirmation;" then the broker will report the offered price before concluding the sale. Copies of letters and telegrams should be kept by the shipper for reference as needed. Shippers experienced in loading carlots seldom have disputes with dealers of high standing.

The shipper should supervise closely the grading, the packing, and the loading of the car. Poor work by helpers at shipping points is often the cause of trouble at the receiving end.

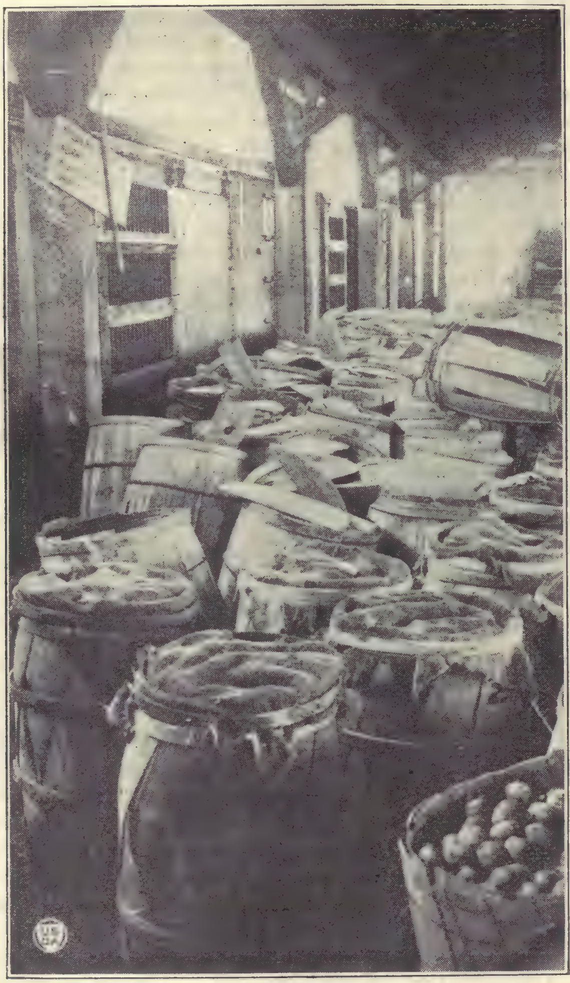

FIG. 8.—Much loss occurs from breakage of weak packages.

PACKAGES.

Packages should be on hand well in advance of the shipping season. While the double-headed barrel seems the best package, other containers cost less and are still used extensively. The cloth-topped barrel is the leading kind in the coast sections north of the Carolinas. The top of cloth or bagging is fastened by driving down over it the top hoop of the barrel and nailing through the hoop and cover.

As the staves have little support at the top, these barrels are not as strong as the double-headed barrel and there is less protection to the contents both at the sides and top. The cloth-top barrel breaks down easily. Still more so, the slat barrel, which is a rather flimsy affair. The slatted type used largely in the Beaufort section has an inside hoop that adds strength but is likely to cause bruises to the contents. Sacks are still used in the South Central States and more or less in other sections, notwithstanding the injury often caused to the contents. The 150-pound sack is used according to convenience and because some markets are accustomed to it. The 100-pound size, used for the western main crop, is easier to handle and if properly loaded in the car the contents are less likely to heat.

Hampers are often used for the very early shipments from southern Florida and Texas. These are sometimes shipped in small lots by express and travel fairly well because handled more carefully than freight shipments. The first arrivals sell at such high prices that buyers often prefer the small package. For the later shipments in car lots by freight the hamper is not satisfactory because of loss by breakage and sometimes by theft. The hamper is also much used for short-distance marketing by truck or wagon. For this purpose it has the advantage of cheapness and convenience.

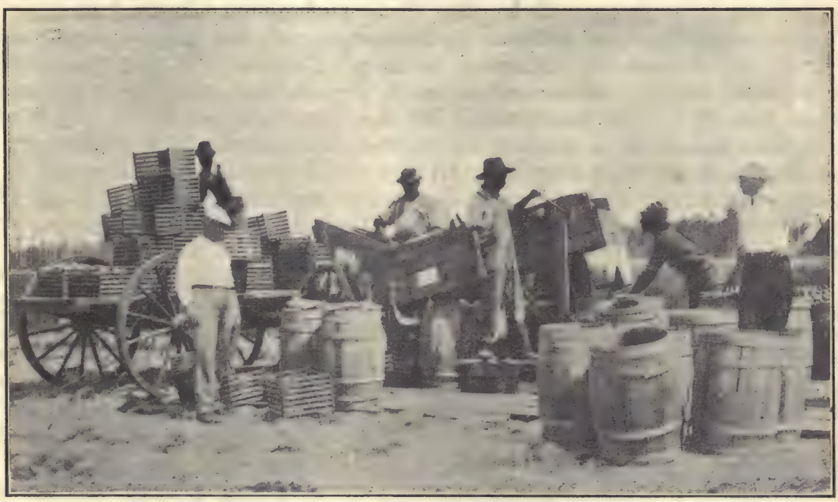

FIG 9.—Field sorting of southern potatoes over a machine into three sizes.

GRADING.

Grading is a kind of market insurance upon which bargaining may be based, contracts made, disputes avoided, and losses adjusted. It protects shippers and buyers by supplying a standard of quality and a basis on which disputes and heavy losses may be avoided. It does much to reduce the difference between the price paid to the grower and the price received by the dealer.

To be of value, grades should be permanent. Individual grades are subject to change at any time. They should be uniform if sales are made in large markets. Hence the value of official grades should be emphasized.

In some of the early shipping regions, as in Texas, for example, grades have been established by State law and shipping-point inspection made available. The inspector is paid a fixed price by the shipper for each certificate of inspection. Many shipping organizations, like those in Virginia and Maryland, have their own grades and hire their own inspectors to make sure that the shipments will be up to standard.

ICED CARS.

In the southern sections, where the barrel container is used, most shipments are made in ventilated cars. California and several other main-crop States, which market also an early crop, find it necessary to ship under refrigeration. Excellent results are secured in this way, but the extension of the practice has been checked by the cost and the difficulty in many sections in securing refrigeration service.

INSPECTION.

There is still the possibility that the buyer will reject the shipment on arrival as not being up to grade or being out of condition. If there is trouble of this sort the shipper may arrange to have the carlot officially inspected by the Federal food products inspector. These inspectors are located in the principal market centers and will travel reasonable distances to inspect on request, on payment of a fee of $4 per car and expenses. The carload may be inspected when placed on the team track at the city railroad yard. This is privately done, as a matter of course, by the dealer's customers. An official inspection may be made by the Federal inspection service upon request by the shipper, dealer, or railroad company, and is usually made in case of doubt raised regarding quantity, grade, or condition. All bills of lading should read "Permit inspection."

The cost of official inspection is a small item but it helps to insure against unfair rejection of the car. The inspector's report, a copy of which goes to the shipper, makes a fair basis for allowance in case the carlot is really defective or if damages are to be claimed from the railroad for undue delay or lack of care in handling the shipment. If the damage was caused during transit, the buyer may accept the car under protest and enter a claim for damages in behalf of the shipper.

Official inspection service at country shipping points has been established in some States. This service has been rendered to some extent by the United States Department of Agriculture and will assure more complete protection to shippers and receivers.

GET ACQUAINTED.

A personal visit to the principal markets during the active season will do much to make clear the market requirements and conditions. The shipper becomes acquainted with his dealer,, learns his point of view, his methods, and his difficulties. He has an opportunity to explain his own problems and to begin an acquaintance which may do much to smooth the way in further business dealings. The grower can hardly realize all the little points that go to make up a good marketable product until he sees the best goods, compares them with those selling for less, and has the salesmen explain the difference.

Once a satisfactory dealer has been secured the shipper should strive to hold his confidence just as hard as the dealer tries to please him. It is a pleasant state of affairs when the shipper praises the selling ability of the dealer and the dealer commends the shipper and makes special effort to hold his business from season to season. The dealer looks for the consignment year after year and his customers begin to ask for the goods, while the shipper takes pride in producing and putting up a product that will meet expectations. The haphazard or occasional shipper who tries a new dealer for every shipment hardly can expect to build up a market standing of this kind.

MISTAKES OF EARLY SHIPPERS.

There is much cut, bruised, and sunburned stock. The skin is the weak feature of the early potato. Part of the trouble arises from careless digging and rough handling. A break in the skin is the open door for rot.

Packages broken on the way cause trouble. The double-head barrel is good protection, and the cloth top fair protection. In some markets there is more or less comment against the double-head barrel used for southern potatoes, on the ground that it promotes decay by checking ventilation; otherwise it is considered by far the most successful package. The trade as a rule is not used to crates and does not buy them readily at full prices. In short, the use of anything but the standard packages used in the section for the same kind of stock must be considered a mistake. Southern potatoes in bushel crates have sold in some markets at 25 cents below stock in barrels—sometimes 75 cents to $1 below barrels—for the same quality and grade of stock. Crates are not so strong as stave barrels and need more careful loading and handling.

Another mistake is the use of old or weak packages. Barrels of thin wood or of slats do not hold up well in carlot shipments for long distances. Old barrels that have held other material may sift powder and dust of various colors and flavors upon the potatoes, affecting their selling quality.

Too many barrels are slack filled. One reason for the popularity of well-known brands is the certainty of getting 11 pecks of marketable potatoes from every barrel. This means shaking down several times while filling and the use of a barrel header. A loosely packed barrel may seem full at first, but settles during the journey.

Loose packing in loading cars is a common fault. Surplus space at the center of the car must be taken up by bracing. Barrels should be loaded on the ends, not on the sides, and long strips of wood should be put on top of them across the row before stacking the second tier of barrels on top of the first. Poor ventilation is common, especially when sacks are used. The load should not be jammed against the car doors, but should be held away by slats nailed across on the door posts. In Farmers' Bulletin No. 1050 are described and illustrated in detail the methods of loading cars with either barrels or bags.

The shipper sometimes fails to send the city dealer a notice stating the number of the car, how many and what kind of packages of each grade and variety are shipped, and by what railroad and route. The bill of lading should be inclosed with the notice. A short, clear statement of the facts needed will get best results.

Disputes concerning the quality of the shipment usually refer to undersize, mixture of No. 1 and No. 2 grades, scab, rot, sunburn or heating, and cuts or bruises. When such defects are serious the shipper must expect to lose the potatoes sorted out, besides the cost of the freight and the labor of handling the culls.

WHAT THE INSPECTORS FIND.

Inspectors in the Federal service at market centers state that many early potatoes are not well graded and include many defects that cause trouble at the receiving end. Some of these defects are illustrated in Figure 10. It is true that the dealers and consumers will often accept more small-sized potatoes and will tolerate various little defects that would not pass in the main crop. When new potatoes are in light supply receivers may accept a car not strictly up to grade because it can be sold at a profit. But when arrivals are liberal and there is plenty of well-graded stock on the market the buyer becomes more particular and perhaps rejects potatoes from the same field from which the earlier shipments came, put up in the same way, and of the same general character. As the shipper can not determine in advance the condition of the market when his shipment may arrive, the only safe plan is to ship carlots that are strictly up to grade.

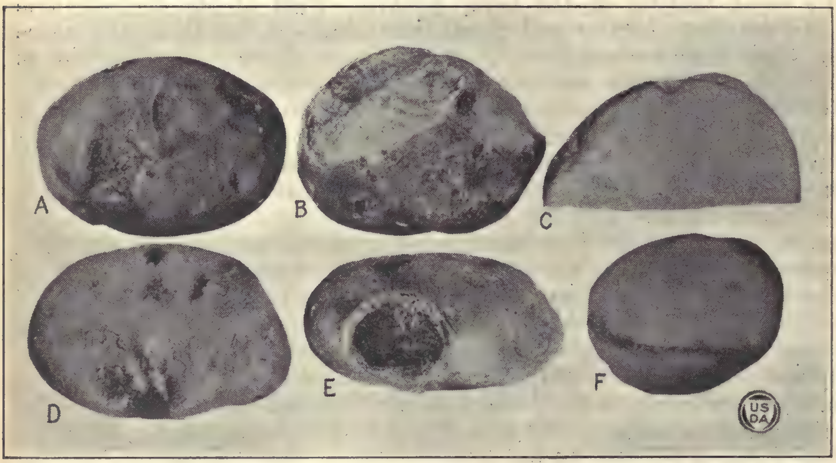

FIG. 10.—Common defects in early potatoes.

A. Slimy soft rot.
B. Cuts and decay.
C. Sunburn.
D. Scab.
E. Grub injury.
F. Bad cuts.

Some whole sections have been conspicuous for shipments of ungraded or poorly graded stock loaded just about as it comes from the field. In seasons of heavy production such sections find their crop hard to sell. The remedy is for the growers in such districts to get together and put up potatoes according to a common standard.

Much early stock is covered with mud and dirt, the result of digging the potatoes during a wet time. Some of the mud comes off during shipment and causes shrinkage in weight. The rest stays on and affects the appearance and market value.

The most serious loss resulting from marketing muddy potatoes, however, is slimy soft rot. The handbook used by the official inspectors says of this decay:

> In wet soil the bacteria may enter the potato through scab wounds, through the breathing pores of the tuber, or through broken places in the skin.
>
> If infected potatoes are dug while wet and scalded by exposure to the hot sun, or if sacked with wet soil adhering, a procedure which may lead to heating or sweating, the rot may progress rapidly from the surface inward throughout the whole tuber.
>
> Control measures are: Careful sorting of stock which has been subjected to unfavorable conditions before it is put into transit or storage, and improvement of handling methods to avoid wounds and scald.

This rot progresses very rapidly in transit and storage, but can be checked by rapid drying of affected stock.

Sun scald is a serious defect resulting from exposure of the newly dug tuber to the direct rays of the sun for too long a period. This should not be confused with potatoes which have been turned green by long exposure to light. This condition is properly termed sunburn. The vegetable disease handbook describes scald as follows:

> Scald on potatoes may appear just as large blisters which soon become sharply depressed or as slightly bleached areas with a very irregular and lobed margin of a darker metallic color. Upon cutting such a tuber, it is found that a shallow surface layer of tissue has been killed. This killed tissue is a dull gray in color and is separated from the uninjured tissue by a brown and very irregular line.
>
> Scald is of the highest importance from the market point of view. The killed tissue is very subject to the attacks of rot-producing organisms such as Fusarium and especially the bacteria of slimy soft rot. In the Chicago market in the summer of 1918 there were enormous losses due to slimy soft rot following scald in shipments of potatoes from the South and the entire Mississippi Valley.

Scab is one of the most common blemishes of early southern potatoes. It is useless to try to build up the reputation of the brand unless noticeably scabby stock is kept out of the pack. Damage by wireworm is also common in various sections in some seasons.

OBJECT LESSONS IN MARKETING THE COMMERCIAL CROP.

Methods of handling and distribution are likely to be at their best in the leading shipping sections, where large groups of shippers (under stress of the busy market season year after year) have gradually settled upon methods found well suited to the conditions. A part of their growth and success is based on a steady building up of facilities which gives them an advantage of one kind or another in the markets. The large volume of business to be done in the short time and the rivalry of competing firms naturally lead to methods that will save in labor and in cost and bring the best returns. The growers and dealers near small shipping points or in new sections may profitably note the methods used at leading shipping points. Often one shipping center may obtain helpful hints from the practices in others. For this purpose several descriptions by field representatives of the Department of Agriculture follow, giving in brief the story of the early crop as handled at leading centers of production and shipment, but including also a few shipping sections in which systematic marketing has not been fully developed.

Among the largest and most fully developed shipping sections are those along the Atlantic seaboard such as Hastings, Fla., the Beaufort and Charleston sections in South Carolina, the Norfolk and Eastern Shore sections of Virginia, the Eastern Shore of Maryland, and southern New Jersey. Important sections farther west are the Eagle Lake district of Texas, the Arkansas Valley of Oklahoma and Arkansas, and the Kaw Valley of Kansas.

HASTINGS, FLA., THE FIRST OF THE EARLY-POTATO SECTIONS.

The first of the important early potato-shipping sections is the Hastings district in northeastern Florida. This includes part of St. Johns, Putnam, and Flagler Counties. Including the boat shipments from points on the St. Johns River, the annual movement of potatoes from this territory is 1,500 to 3,000 cars. The market movement occurs chiefly between April 1 and May 15. Spaulding Rose is the chief variety raised. Because this is an early potato and because shipments from Florida usually are sent to market as soon as the crop can be harvested, it is not surprising that many of the potatoes are immature and need careful handling.

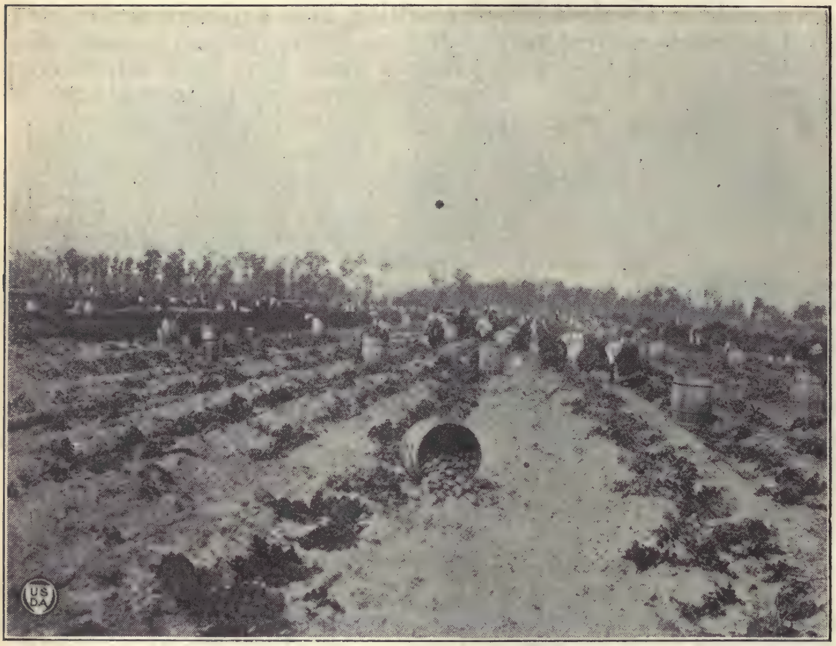

FIG. 11.—Harvesting potatoes in the section of Hastings, Fla.

The principal container used is the double-headed barrel. Occasionally, cloth-top barrels and, in times of barrel shortage, sacks containing 150 pounds have been tried.

The potatoes are picked into field crates or other containers and hauled direct to the sizing machine. The better growers instruct their pickers to leave defective or diseased potatoes in the field. The machine may be set up in the field or be placed under some shed. The smaller machine for growers with a comparatively small acreage is operated by hand. Power to drive the larger machines is supplied by gasoline engines or electric motors. The potatoes are emptied from field crates on the apron or receiving bin of the machine, from which they are carried to the first belt. This top belt of 1$\frac{13}{16}$ inches mesh carries all the potatoes of No. 1 size up the machine over the end of the belt where they drop through the chute into the barrels for the first grade. The No. 2 and smaller potatoes drop through the 1$\frac{13}{16}$-inch mesh on a second belt of 1½-inch mesh. Here the No. 2 grade are carried up the machine and dropped through a chute at one side into a barrel. When the market will warrant shipping the No. 3 grade, a third chain or belt is used, and potatoes which do not drop through its 1¼-inch mesh are carried to the chute on the opposite side. Considerable bruising may be avoided by providing an apron to break the fall as the potatoes are dropped into the barrel.

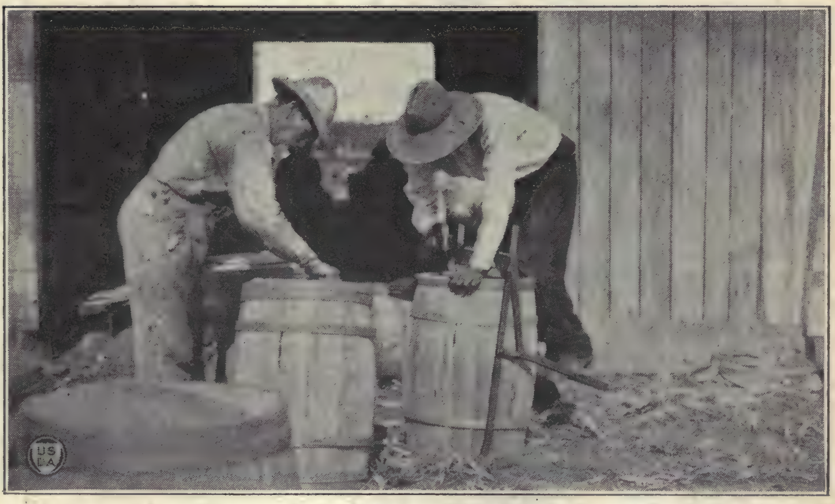

Fig. 12.—The use of a barrel header makes a tight, safe pack.

The machine sizers are usually called graders, but this is only partially true, for no machine removes diseased or defective potatoes. When properly run, it will size potatoes better than the human eye. Manufacturers of these sizers are now providing a sorting belt in addition to the sizing screen. This gives an opportunity to remove the cut, bruised, misshapen, and diseased potatoes overlooked by the field pickers.

Most of the potato shipments from Florida go by rail. Stock grown at points on the St. Johns River is carried by boat to Jacksonville and then is transferred either to cars or to coastwise steamers. From one-half to two-thirds of all potatoes from this section are billed from the Hastings station. Because of the distance to the consuming markets, at least one-third of all the cars are billed to prominent diversion points, such as Waycross, Ga.; Potomac Yards, Va.; or Cincinnati, Ohio. This gives shippers an opportunity to change the destination in transit and to reach markets that have advanced since the cars rolled from Florida. New York, Philadelphia, Pittsburgh, Chicago, Baltimore, and Washington are among the leading cities receiving Florida potatoes in large quantities. Cincinnati, Cleveland, and Detroit also take heavy shipments. Nearly all big markets east of the Mississippi River use a few carloads of Florida potatoes.

Potato raising is the main source of farm income in this section of Florida. The acreage and distribution have increased rapidly. Hastings is a busy town during the months of April and May. Buyers throng the place. Local operators work their forces to the limit. It is necessary to harvest, grade, pack, and ship an average of 75 cars of potatoes a day during the brief season, as of course, no commercial stocks of southern or early potatoes can be held in storage.

Although there are many independent buyers on the ground when the shipping season opens, the deal is largely controlled by prominent commission houses which assist in financing the farmers. Contracts are made that require a large part of the crop to be sold through these houses on commission, the usual rate being 5 to 10 per cent. These firms maintain local offices at Hastings during the season and the wires are kept busy soliciting and filling orders.

A little over two-thirds of the acreage in the principal Florida potato-shipping region was reported grown under contract in 1922. In such cases the dealers advanced $15 to $20 per acre to pay cost of growing the crop or indorse the growers' notes, charging 8 per cent. The dealers supplied seed and barrels and sometimes the fertilizer, although the tendency is to leave this to the fertilizer companies. These charges come out of the crop before the grower gets anything. Often the dealers advance enough more money at harvest time to pay for digging and loading the crop. In the event of a bad season the grower receives no returns from the sale of his crop, and if the agreement requires it, he has to give a note for the rest of the money and materials advanced. Practically all potato crops have paid enough to meet such loans when fertilizer had not been included in the advance. The dealer gets interest on the money, a profit on the seed stock and barrels, and 5 to 10 per cent commission for selling the crop. The growers who, either alone or as members of an association, do not depend on a dealer, are in a position to buy seed and supplies at lowest prices and to save for themselves a part of the interest and various profits. Moreover, these growers are in a more independent position at harvest time, since they are not bound to sell the crop to any one dealer.

More recently, the consignment method of selling, which depends for its net returns on the condition of the northern markets on arrival, has been changed partly to an "f. o. b. cash track" basis. This latter method insures prompt cash returns to shipper and grower, because the potatoes are sold in the car before shipment, the buyer paying the freight and all subsequent costs of handling.

Most of the buyers or operators in the Hastings section have business connections in the leading markets. Since New York City is the principal outlet for these potatoes, the New York jobbing price is the chief factor in determining the f. o. b. price at Hastings. The day's market price usually is fixed in the late morning or by noon. Price news and other information useful in governing sales and shipments is obtained from the local office of the Bureau of

Agricultural Economics, operated at Hastings each spring. Most sales are completed in the afternoon, and there is a rush of car loading every evening, sometimes continuing until late at night. Nearly all of the work is done by colored labor, and wagonload after wagonload of the barreled potatoes fill the driveways near the car doors. By midnight the day's work is done, and the long trains of loaded cars are on their way north.

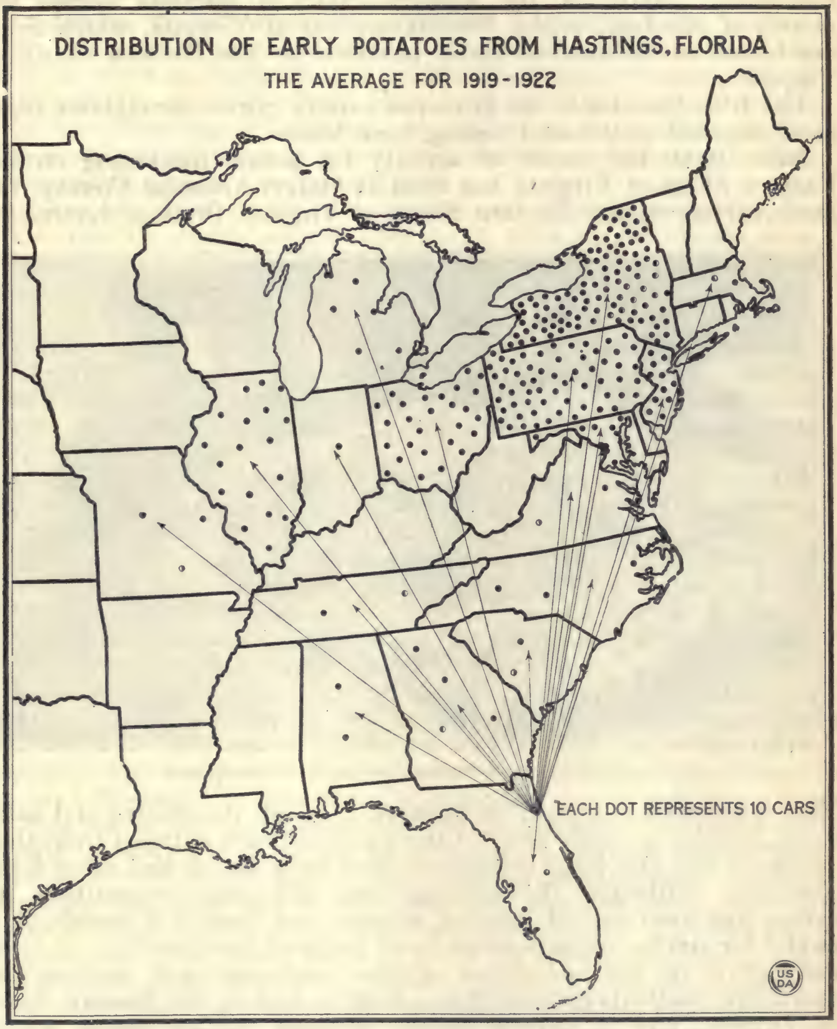
DISTRIBUTION OF EARLY POTATOES FROM HASTINGS, FLORIDA
THE AVERAGE FOR 1919-1922
EACH DOT REPRESENTS 10 CARS
USDA

FIG. 13.—The majority of Florida potatoes go to northeastern city markets.

EASTERN VIRGINIA THE LARGEST EARLY SECTION.

The eastern shore of Virginia is one of the most compact of the early potato sections and, during June and July, is the most important potato-shipping territory in the United States. From the two counties, Northampton and Accomac, constituting the Virginia portion of the peninsula between the Chesapeake Bay and the

Atlantic Ocean, 12,000 to 15,000 carloads of white potatoes are shipped within 60 days. About 70 miles long and varying from 5 to 20 miles in width, this territory has only one railroad. Several important shipping points are reached by boats operated by the railroad company (see Fig. 14). Just north of this section, in the peninsular part of Maryland, is the potato-producing territory known as Eastern Shore of Maryland, with its market center at Pocomoke. South of the Eastern Shore of Virginia, across the mouth of the bay, is the Norfolk section of Virginia, which ships one-fourth to one-half as many potatoes as the Eastern Shore of Virginia.

The Irish Cobbler is the principal variety grown throughout these sections, most of the seed coming from Maine

Since 1900, the center of activity for potato marketing on the Eastern Shore of Virginia has been at Onley, Accomac County, the headquarters of the Eastern Shore of Virginia Produce Exchange.

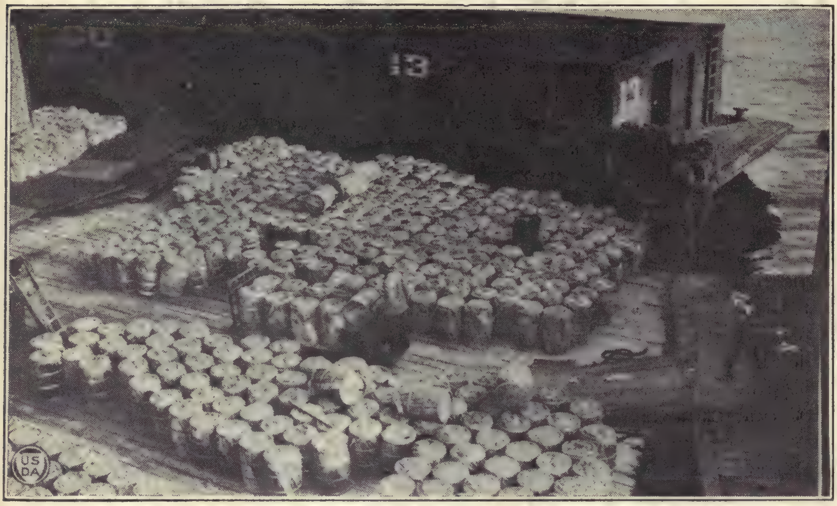

FIG. 14.—Norfolk boat shipments include much barreled stock.

This joint-stock company of growers, through its officers and sales force, handles not only most of the white potatoes shipped from that territory, but also large quantities of sweet potatoes and other farm products. Although the exchange has met some competition, its career has been one of marked success, and to-day it stands as a model for similar organizations in all parts of the country. A brief description of the operations of this exchange will explain the marketing methods prevailing to a large extent on the Eastern Shore of Virginia, and in several potato sections further south, where market operations are carried on by associations modeled after the older organization in Virginia.

The several thousand farmers who are stockholders in the exchange agree to market their products through this organization. The exchange acts as sales agent and, in addition, serves as purchasing agent for seed potatoes and other supplies needed by the growers. For convenience in marketing, the central exchange at Onley has established 50 "locals." Each has a resident manager, an inspector, and a director, the latter representing the local group at the meetings of the central organization. The managers conduct the general business of the exchange in their respective districts. It is the duty of the local inspector to see that all potatoes are properly graded, packed, and labeled and to reject undesirable stock. Most of the grading is done by the farmers themselves, who sort the potatoes while picking them up.

In addition to this organization in the producing area, the exchange has market agents in a large number of important markets, chiefly in the New England and the Middle Atlantic States. These agents take the place of city brokers. They solicit and fill orders, handle the collection of accounts, etc. They keep the Onley office of the exchange in constant touch with market conditions and are a most valuable part of the organization.

Because of many years' experience, and aided greatly by the reports from its market agents who are at work before the shipping season actually opens, the exchange is able to advise potato growers when to load cars at the various shipping stations. In this way, the flow of potatoes from country to city points is carefully adjusted to the market to the advantage of all concerned. All shipments are pooled daily. Cars of the same grade loaded on one day return the same price to the grower whether or not the sale is completed on that day and regardless of actual variations in prices for individual cars. By "pooling" the day's loadings in this manner, the shippers are protected from loss through sudden changes in market price. The exchange operates on a commission basis not to exceed 5 per cent or not more than 20 cents per package. Nonmembers pay 3 per cent additional. All expenses of the exchange are paid from this fund and an annual dividend paid to stockholders. The remainder of the fund is divided between the "reserve fund" and the shippers, prorated according to the amount of commission assessed on the produce each has shipped through the exchange.

On the wall of one of the offices at the Onley headquarters is a large record board, with a space marked off for each of the 50 loading stations. The telephone rings soon after the opening of the office in the morning; it is part of the exchange's private telephone system. The local manager at Exmore, for example, is on the line. He reports a car or cars of potatoes loaded that morning and ready for shipping orders. He gives the number and initials of the car and the siding on which it stands. The contents are described, number of barrels, the grade and marks, and the name of the grower or growers who loaded the car. If the potatoes are No. 1's, the cloth tops bear the "Red Star" mark. If No. 2's are in the barrels the tops are not marked, unless the potatoes have been machine graded. In the latter case, they bear the "Gearwheel" brand. On the basis of these standard marks the exchange has built up a reputation for well-graded, reliably packed potatoes.

A card bearing this information is prepared, and as fast as the loaded cars are reported to the main office of the exchange, the descriptive cards are hung on a hook under the proper station names, thus telling at a glance the number of cars of potatoes available at any time and their location. A loaded car usually contains 200 cloth-top stave barrels and all are United States standard barrels.

The exchange has private wires to Philadelphia and the commercial telegraph companies have stations in the building of the exchange at Onley As inquiries and orders come over the wires from its market agents in leading cities or from brokers or dealers at other points, the exchange fills the orders from the loaded cars on hand and transfers the cards to squares marked on the lower portion of the board, with a complete record of the sale written on each card.

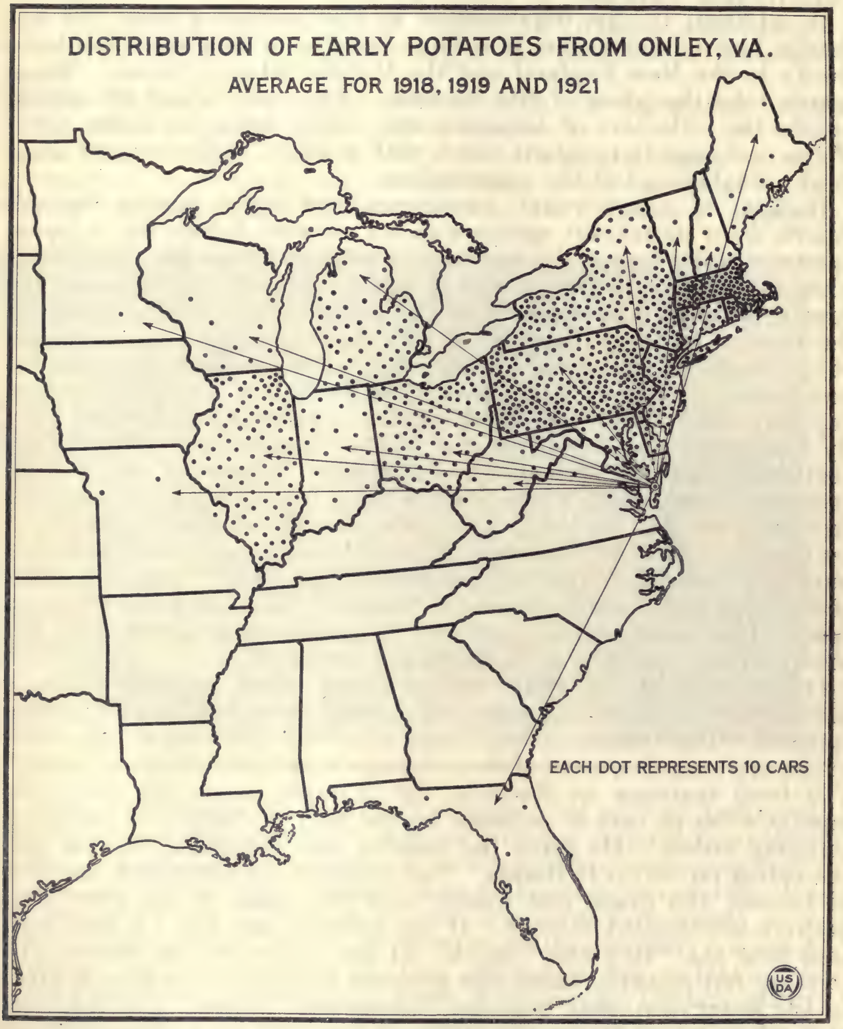
DISTRIBUTION OF EARLY POTATOES FROM ONLEY, VA.
AVERAGE FOR 1918, 1919 AND 1921
EACH DOT REPRESENTS 10 CARS
US DA

FIG. 15.—Eastern Shore ships to most of the northern markets.

The upper part of the wall board, therefore, shows what potatoes are ready for shipment and the lower part of the board shows all cars sold that day. This board helps one to measure the demand and movement. The cards become the basis of the records in the accountant's office, and the permanent file of cards presents a valuable history of the business.

Most of the sales are made on an "f. o. b. usual terms" basis, the stock being subject to inspection by the receiver before acceptance. This method is followed to the utmost extent practicable. Some of the cars are shipped to commission merchants whom the exchange has found to be trustworthy. Through the exchange, Eastern Shore of Virginia potatoes are distributed to practically all important markets east of the Mississippi River, as well as to certain Canadian centers and to Cuba.

A TEXAS SHIPPING SECTION.

While the eastern part of the United States is receiving new potatoes from Florida and the far western markets are obtaining new stock from the Los Angeles section, the midwestern cities look to Texas and adjoining States for their earliest supplies. The Eagle Lake section of Texas, in the heavy black-loam region not far west of Houston, usually ships 1,000 to 1,500 carloads during the last half of May and the early part of June. This territory covers part of Wharton and Colorado Counties, and about half of all potatoes from the districs originate at and around Eagle Lake station. The Bliss Triumph it the leading variety.

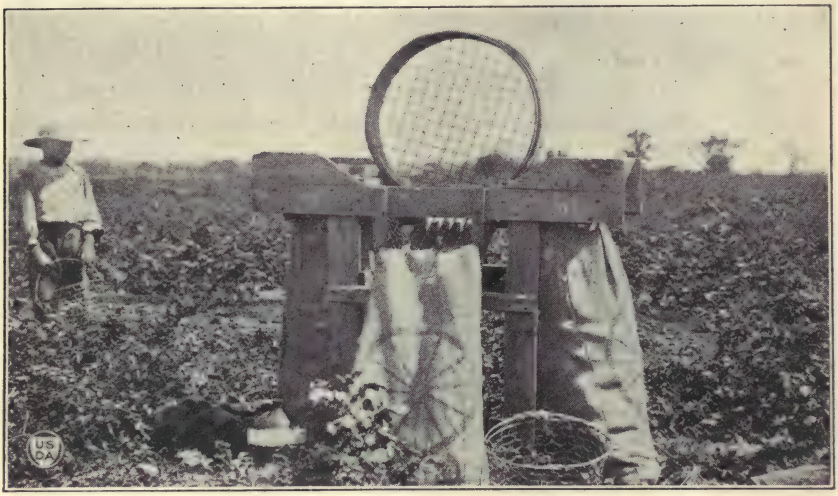

FIG. 16.—Screen sizers have been largely replaced by sizing machines.

The soil in which potatoes are produced in this section presents one of the marketing problems. Although the rule is to sort out the larger, or No. 1, stock by means of either hand screens or machine graders, the heavy soil sticks to the potatoes. This is particularly true when harvesting is done after a rain. The quantity of soil clinging to the potatoes sometimes affects their market value and in nearly all shipments 2 to 4 per cent of weight must be allowed for dirt, which falls off before the shipments reach their destinations.

The principal container is the 2-bushel sack, which is generally filled and closed in the field and hauled in wagons or trucks directly to the cars. Most of the work is done by Mexican or negro labor. The contents of a sack usually weigh from 100 to 110 pounds. Shipments from Eagle Lake and neighboring territory are usually made in stock cars, a kind of equipment that does not always afford the best protection from sun or rain. From Simonton station and adjacent points many shipments are forwarded in ventilated refrigerator cars, which afford better protection.

Chicago is the leading market for new potatoes from Texas, with Kansas City and St. Louis ranking next. Many cars are "rolled" for diversion, subject to a change of destination while en route. This enables the shipper to divert cars to those points where there is a greater demand.

The marketing of the crop is largely in the hands of a few commission firms, who not only serve as selling agents, but who lend money to growers before the crop is sold. Contracts are drawn up, whereby these houses furnish the seed, part of the sacks, and other things needed in producing and harvesting the crop. In return, the firms have the privilege of selling part (or all) of the potatoes on the usual commission basis or at a flat rate per car. They have offices at Eagle Lake during the shipping season and handle most of their business by wire, selling on an f. o. b. basis. Of course, there are some buyers on the ground who purchase many carlots, but the large operators control most of the sales.

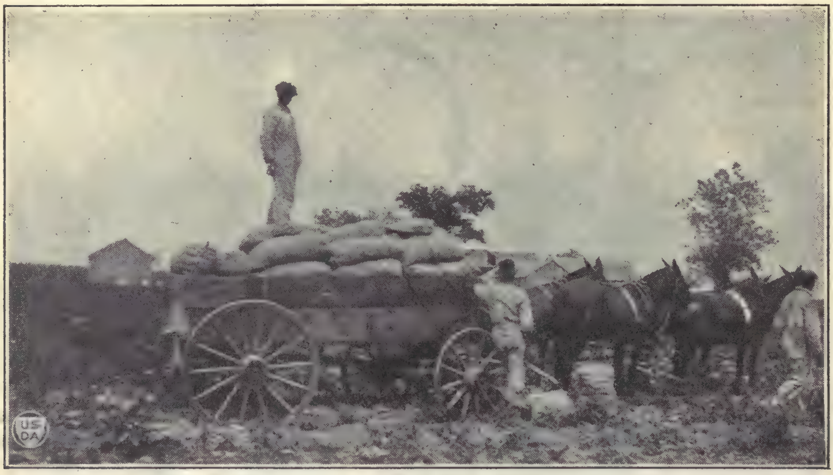

FIG. 17.—In the Southwest many potatoes are bagged in the field.

SOUTHERN NEW JERSEY, A SECOND EARLY SECTION.

The southern New Jersey early-potato section is in the intermediate class with Kentucky and Kaw Valley, Kans., although a little later in maturity of the crop. It supplies chiefly the eastern markets in late summer and early fall, following the Eastern Shore crop closely and competing to some extent. The section in southern New Jersey, and the one in the northern part of the State, market their crops in close succession. As with other intermediate sections, the conditions vary according to the earliness and volume of the southern crop and of the main northern crop. Sometimes there is a favorable early outlet for the bulk of the crop. In other seasons the markets do not encourage immediate shipment and much of the crop is held for gradual disposal. The area of distribution is wide, including the whole eastern half of the country, but New Jersey and neighboring States—Pennsylvania and New York—take most of the crop. Many early shipments go to New England cities and west to Chicago and St. Louis; later shipments go south as far as Florida and Louisiana.

Potatoes may be sold by the wagonload for cash to local dealers, who in turn sell loaded cars to cash buyers or on f. o. b. orders by telegraph from city dealers or through brokers. Cooperative exchanges are a feature in both northern and southern New Jersey. One of these in Monmouth County handles thousands of carloads yearly. Competition among buyers is often keen in southern New Jersey whenever dealers need stock to complete carloads or when extra choice lots of potatoes are offered. The stock is sacked at the car door or shipped in bulk, having been graded by the growers. It is sold on the 100-pound basis and put up mostly in 150-pound sacks. In northern New Jersey, machine graders are operated at the car door or in the warehouse at the car door or in the warehouse at the shipping station. Stock sold in the Philadelphia market is put up in five-eighths bushel baskets, and is usually handled by commission men. In the matter of carload consumption of the New Jersey crop, the leading markets in the order of their importance are New York City, Newark, Chicago, Jersey City, Philadelphia, and Boston.

KENTUCKY POTATOES.

The early-potato section of Kentucky, centering around Louisville, is an example of a district which takes full advantage of certain favorable conditions. The section is centrally located and freight charges are about equal to leading markets, north, south, and west. The crop matures in July and early August at a time when main-crop potatoes are not yet in the market and many southern sections are cleaning up the early crop. The shipper must watch crop maturity, shipments, and prices in other sections, and ship north, south, east, or west, according to the indicated demand. This diversified demand for the crop stimulates competition between local buyers who pay cash, handle the crop, and assume the risks of marketing. Shipment is mostly in 150-pound sacks, about 200 to the carload. Some of the stock is United States grade No. 1, other lots are only partly graded. Much of the grading is done on the farms with small field graders with two diagonal screens, the upper one having 1⅞-inch mesh and the lower 1½-inch mesh.

THE KAW VALLEY SECTION.

Another section favorably located to supply the markets during the season between the early and main crops is Kaw Valley, Kans. Together with Kentucky, it supplies a large part of the demand of middle-western and southwestern markets for a month or two in late summer. More or less competition comes from the far West and in some seasons from New Jersey or the Eastern Shore of Virginia and Maryland. Here, as in Kentucky, the outlet varies with the earliness or lateness of the season. If northern crops are late or southeastern crops early, Kaw Valley potatoes go far to the north and east. Ordinarily, Kansas, Missouri, and Oklahoma are the principal consumers, although many cars are reshipped from receiving points in those States. Shippers watch the news bulletins published at Kansas City, reporting shipments and market information and change the route of the shipment accordingly. Heaviest unloads of Kaw Valley potatoes are at Chicago, Denver, Kansas City, St. Paul, Minneapolis, St. Louis, and Cincinnati.

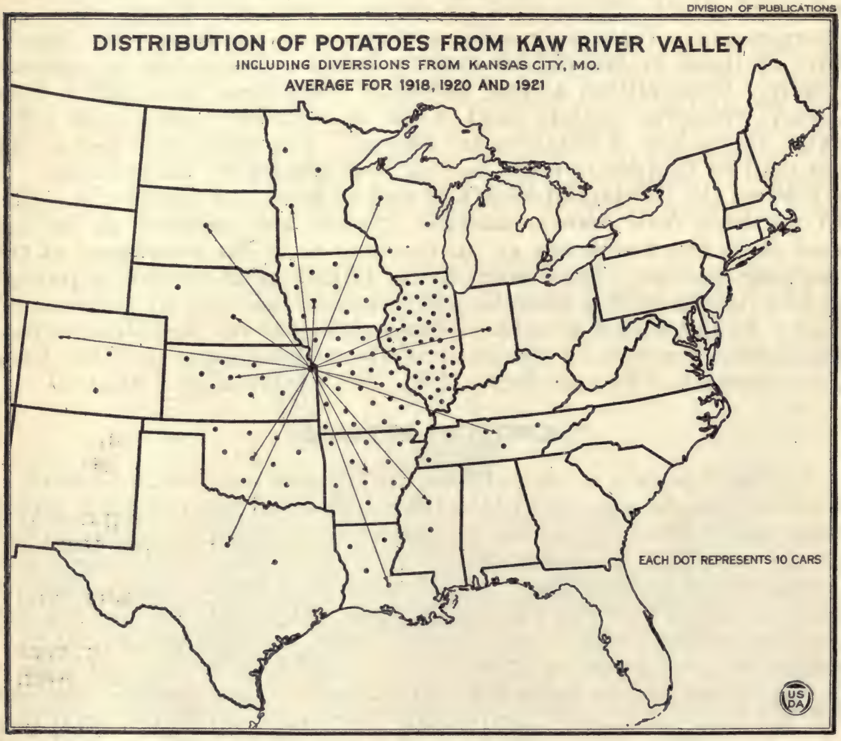
DIVISION OF PUBLICATIONS
DISTRIBUTION OF POTATOES FROM KAW RIVER VALLEY
INCLUDING DIVERSIONS FROM KANSAS CITY, MO.
AVERAGE FOR 1918, 1920 AND 1921
EACH DOT REPRESENTS 10 CARS
US DA

FIG. 18.—Kaw Valley potatoes reach South Central cities in July and August.

TO SUM IT UP.

Early potatoes are important as a cash crop. Yearly shipments are 40,000 carloads or more, worth some $30,000,000, besides many more sold or used in small lots. Prompt, quick, careful handling is the keynote of the market problem.

Plan and study carefully, act promptly.

Plant somewhat according to the outlook for the general market supply likely to be on hand at the time of selling your crop. Study the latest crop estimates, shipments reports, and figures of stocks on hand. Light main crops nearly always mean a good opening for the early crop the next spring. Large main crops much above the five-year average of 373,000,000 bushels and heavy shipments suggest caution. Watch acreage and condition reports from earlier sections. If they plant heavily, later sections will be likely to do the same, which usually means heavy supplies. Bad weather conditions for the earliest sections are favorable for heavier planting farther north. High prices of potatoes at time of planting is one of the best signs. Study past seasons until you have a clear idea of how things usually work out for the early crop. Nobody can hit right every season, but study is better than guesswork.

Watch the markets as you go along. Be sure your name is on the mailing list of the nearest market station and field station. Get the State and local crop reports. Don't be ruled by rumors. Study the best official reports as a habit, until it becomes possible to size up their practical meaning almost at a glance.

Local markets are important, especially in thickly populated northern early sections. There is keen demand for the first early local potatoes, and selling problems are easy. Army posts and naval stations in the vicinity are sometimes good customers.

For the bulk of the early southern crop the choice is between local cash dealers or associations, or shipment on consignment. If there is free competition, local sales are safest. Well-managed associations whose members borrow their money through banks are in a position of advantage. Producers of less than carloads must combine or sell to local buyers.

In some districts and in some seasons much stock is shipped to commission dealers. These men should be picked out carefully for good standing and square dealing.

A good dealer deserves a good shipper. When each learns that he can depend upon the other for fair and reasonable treatment, there is a chance for both to prosper. Know your dealer, then stick to him and make him a friend.

Efficient grading and inspection are great helps in making a solid market basis for the produce and in avoiding grounds for trouble with buyers.

Raise the standard early kinds, adopt the standard grades, and use the packages approved in the district.

Dig quickly at the right time, but oversee carefully to prevent sunburn, rot, cracks, and bruises. Grade well and put up full, even weight. Load with attention to security and ventilation.

Arrange with the dealer in advance and tell him what he needs to know as your agent.

Common mistakes include careless digging and handling, poor sorting and grading, dirty stock, loose, weak packing, loose loading, poor ventilation, failure to send notice of shipment to the dealer, mixed or nonstandard varieties, and unusual packages.

Try to learn something new from the way the crop is handled in other sections.

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Production of Late or Main Crop Potatoes. Farmers' Bulletin 1064.
How to Grow an Acre of Potatoes. Farmers' Bulletin 1190.
Potato Production in the South. Farmers' Bulletin 1205.

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POWERS, W. L. and JOHNSTON, W. W.
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1317

MARKETING MAIN - CROP POTATOES

THE WISE OR UNWISE marketing of the potato crop may easily mean a difference of millions of dollars in the farmers' income in a year. When every principle of intelligent production has been applied and bountiful yields obtained, all profit is too often sacrificed when the crop is sold.

The potato is foremost in value among our vegetables. It is the chief money crop of large areas, an important staple in many others, and is grown for home supply and local markets in almost every farming district.

This bulletin discusses some of the underlying facts and conditions that influence prices, the sources and character of the information the grower should use, and the differing marketing problems of the producers of the late or main crop. The location, shipping season, and relative importance of the heavy shipping districts are shown, with brief descriptions of the methods of marketing pursued in typical areas.

Washington, D. C. Issued August, 1923

MARKETING MAIN-CROP POTATOES.

By **Wells A. Sherman**, *Specialist in Charge Fruit and Vegetable Division;* **George B. Fiske**, *Investigator in Marketing Fruits and Vegetables;* and **O. D. Miller**, *Scientific Assistant in Marketing, Bureau of Agricultural Economics.*

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THE MAIN OR LATE-POTATO REGION.

THE LATE or main crop of potatoes comprises about four-fifths of the total production. As compared with the early crop, the most important feature is its keeping quality, which permits its sale and use all winter and through the early summer of the following year, thus requiring different methods of marketing.

The main-crop region extends from Maine westward to Washington, and southward to northern New Jersey in the East, and to northern California in the West. The States along the southern border of the main-crop territory are somewhat intermediate in character. Thus, New Jersey is often classed as an early-shipping State and California as a main-crop State; both of them, however, are heavy-shipping sections in each class in varying proportions, according to season and market. Some of the late-producing States sell most of their market crop in small lots for local consumption. Only 15 States are prominent in late car-lot shipments. These, arranged according to the average yearly number of car-lot shipments, are Maine, Minnesota, Wisconsin, Michigan, New York, California, Colorado, Idaho, North Dakota, Washington, Pennsylvania, Nebraska, Oregon, South Dakota, and Montana. These States furnish all but a few thousand cars of the main-crop shipments. They move from 110,000 to 200,000 carloads and average about 90,000,000 bushels of potatoes each season.

WHAT IS DONE WITH THE CROP.

About 58 per cent of the combined early and late potato crop of 1919 was reported sold, according to the census returns. Evidently 42 per cent of the potato crop was retained on the farms. Allowing 10 per cent of the total crop for seed and 20 per cent more for shrinkage, stock feed, and decay, there remained about 11½ bushels per farm to be eaten by the people on the 3,000,000 farms which produce potatoes.

The census report says that only about one-half of the farms produce potatoes even for home use, so, evidently, part of the potatoes not sold in city markets are used on other farms. Apparently about one-third to one-half of the potatoes sold are not shipped in carload quantities, but are trucked directly to market or sold from the farms in small lots.

For the season 1919–1920 the shipments of potatoes were about 167,000 cars, aggregating over 100,000,000 bushels. If the car-lot shipments may be considered chiefly for city consumption and the small-lot sales to be consumed chiefly by the rural population, it would appear that city and country customers consume nearly equal quantities. It is plain that much the larger part of the crop is held in the country, but besides local sales and the requirements of the farm families, the country holdings include the greater part of the quantity accounted for by shrinkage, decay, feed for stock, and for seed.

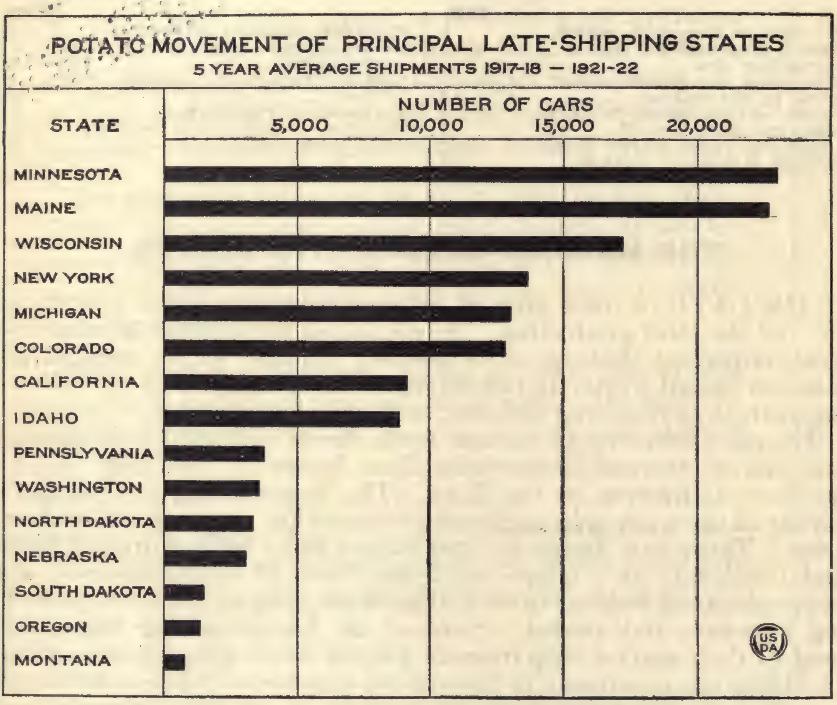

FIG. 1.—Relative importance of potato-shipping States.

The disposal of the average potato crop is indicated on a different basis in Figure 3, using the average of estimated crops 1917–1921. Making the same 30 per cent allowance for waste, seed, etc., and taking out about 25 per cent as shipped in car lots, there remains about 45 per cent of the crop to be sold in small lots and consumed on farms.

About half the total crop, then, is used on farms in one way or another, including losses and waste. The other half is sold, being disposed of in about equal proportions as car-lot shipments and as sales in small lots.

The marketing problem, which makes or breaks the grower, is really the problem of selling about half the potatoes actually grown. A part of the 10 per cent estimated as used for seed goes into the car-lot movement in addition to the 24.2 per cent credited mainly to city consumption.

PROPORTION OF THE CROP SHIPPED.

Table 1 shows the total production for each main-crop State, the number of carloads shipped from each State, and the percentage of the crop of each State which these shipments represent. The percentage of the crop shipped as carloads shows in a general way the extent to which the crop is grown for sale upon the general market through the usual channels of commercial distribution. Some of these figures have a vital bearing upon successful marketing.

TABLE 1.—*Five-season average production, car-lot shipments, and percentage of potato shipments from main-crop States, 1917–18 to 1921–22 seasons.*

HEAVY SHIPPING STATES.

	Production.		Car-lot shipments.	Percentage of crop shipped.
	Bushels.	Cars of 600 bushels.		
Idaho	7,536,800	12,561	8,896	70.82
Colorado	11,611,000	19,351	12,814	66.21
Maine	25,120,600	41,868	22,610	54.07
California	11,307,800	18,846	7,358	39.07
Minnesota	30,870,000	51,450	22,983	44.46
Nevada	1,097,600	1,829	742	40.69
Wisconsin	30,302,000	50,503	17,218	34.50
North Dakota	7,256,800	12,095	3,489	28.04
Washington	8,141,200	13,569	3,728	27.84
Michigan	30,979,000	51,632	12,976	25.13
New York	36,729,000	61,215	13,690	22.36
Nebraska	9,039,200	15,065	3,176	21.08
Oregon	5,458,000	9,096	1,492	16.40
South Dakota	6,449,000	10,748	1,644	15.29
Utah	3,003,600	5,006	675	13.48
Montana	4,781,000	7,968	849	10.65
Wyoming	2,917,400	4,862	480	9.87
Pennsylvania	24,961,600	41,603	3,930	9.44
Total	257,561,600	429,267	138,750	32.32

LIGHT SHIPPING STATES.

Iowa	8,295,200	13,825	533	3.85
Vermont	3,260,000	5,433	130	2.39
New Hampshire	2,173,400	3,622	67	1.84
New Mexico	620,800	1,035	16	1.54
Illinois	8,912,600	14,854	148	.99
Ohio	10,598,600	17,664	161	.91
Connecticut	2,454,800	4,091	20	.48
West Virginia	4,976,000	8,293	26	.31
Indiana	6,074,000	10,123	28	.27
Massachusetts	3,803,400	6,339	16	.25
Total	51,168,800	85,279	1,145	1.34
Grand total	308,730,400	514,546	139,895	27.18

CAR LOT THE COMMERCIAL UNIT.

Potato growers measure their crops by the acre, the bushel, the barrel, or the 100 pounds. The commercial movement, however, is measured in carloads. A carload does not always mean the same number of bushels or barrels. Although many carloads of the late crop have run as high as 700 to 800 bushels, for the crop as a whole in average seasons and for the late crop separately 600 bushels, or 18 tons, is reckoned a carload.

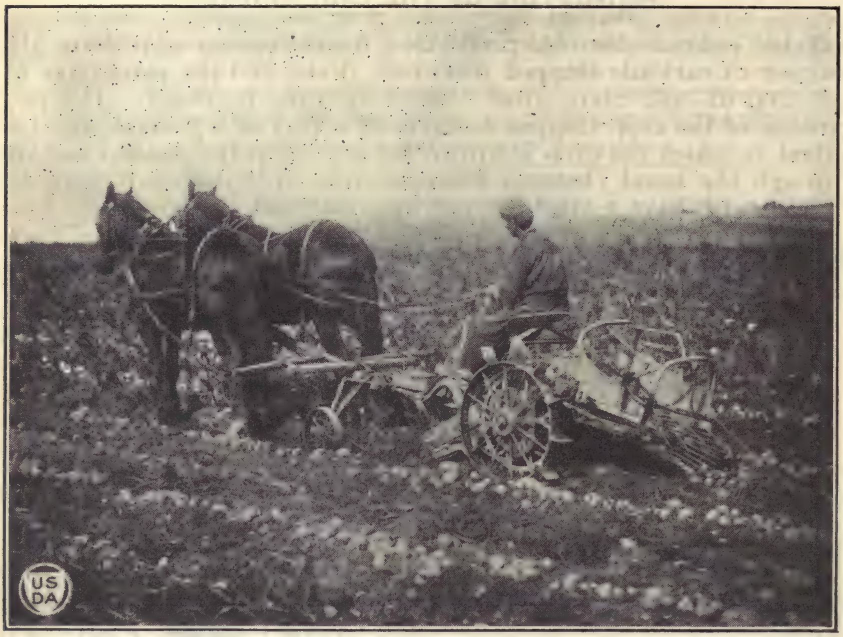

FIG. 2.—Digging main-crop potatoes.

THE SELLING IDEA.

Marketing is comparatively simple when conditions favor the producer. Potatoes sell easily at fair prices when the supply is not excessive and the demand is active. Buyers are then looking for shipments, and any kind of stock—No. 1, No. 2, or ungraded—finds a ready market. But for the main potato crop such conditions prevail less than half the time. In seasons of heavy production and little speculative demand, when local buyers are hard to suit, only by skillful marketing can the producer hope to get satisfactory returns.

In any season a thorough knowledge of conditions that attend the marketing of potatotes offers a distinct advantage in buying or selling. The well-informed handler of potatoes knows a little better than his neighbors and competitors how and where to sell or buy. He may not be right on every occasion, but in the long run his trained judgment will give him the advantage. The practical question for the grower is how to interpret potato-marketing history and apply its lessons to the selling of his crop from year to year.

Are there any facts or conditions upon which his marketing policy may be safely based?

Is there any market information he can use to aid him?

Can he hold his main crop for the late market with profit or are the risks too great?

Shall he accept the offer of his local buyer or seek a distant outlet?

How can he tell what growers in distant but competing territory are going to do?

Is it possible to foresee an unprofitable season in time to save storage and waste by selling early?

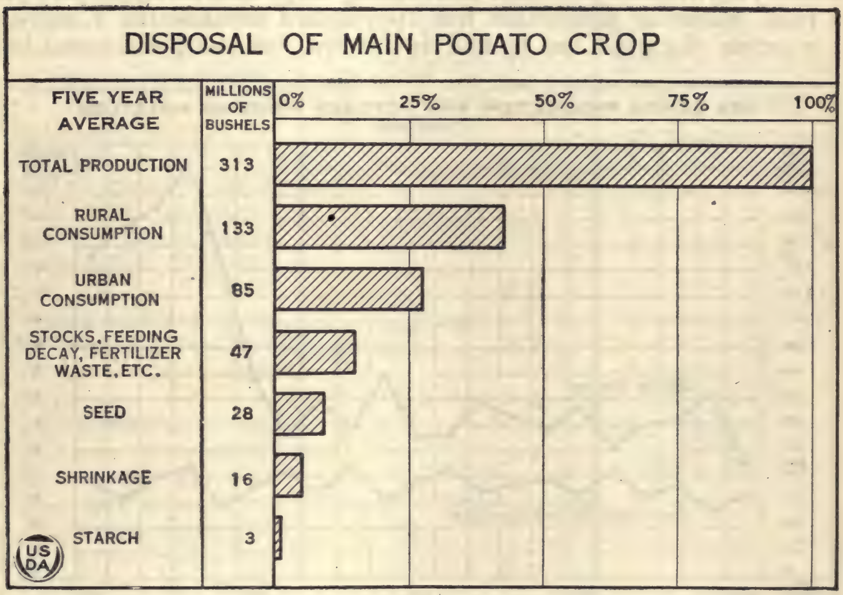

FIG. 3.—Rural consumption of potatoes is heavier than city consumption.

FORECASTING THE MARKET SEASON.

Signs of the probable trend of the coming potato market season appear as early as May, when planting is in progress, and reports of the United States Department of Agriculture indicate in a general way whether the season's acreage is more or less than usual. In average seasons the crop varies according to the acreage planted, but sometimes a large yield offsets a reduced acreage or crop injury causes shortage even from a large acreage. Accordingly, condition reports and crop forecasts must be followed month by month. Reports of poor crops in other sections should encourage the grower to take special care of his own fields in order to be in a position to obtain full advantage from the probable shortage. By August the situation becomes more clear; in September it is still more definite. The Government condition reports and forecasts appear soon after the first of each month and show the probable production.

During the last eight seasons in which the September forecast has been issued the September estimate has been a fairly good guide to indicate whether the crop would be large or small. The August estimate was also a valuable guide, although in most years less uniformly reliable than that of September and the later months.

The general rule (Fig. 4) is to sell as soon as ready for market when the crop is above the average or even when so near the average as to make the outcome seem doubtful. In uncertain cases waiting for later estimates might disclose the situation more clearly.

The rise or fall in winter prices has coincided remarkably with small or large crops, indicating that the frequent occurrence of a high-price season following one of low prices depends largely upon underlying tendency toward alternating large and small crops. As a rule, whenever production has approached or exceeded 4 bushels per capita the price has tended downward, but the price trend has been upward whenever the average yield fell below 3.2 bushels per capita.

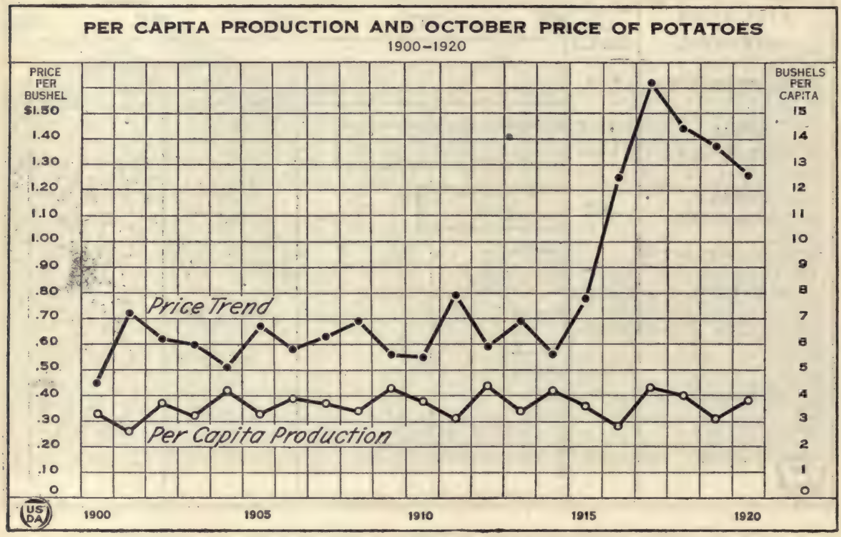

FIG. 4.—Potato prices move up and down, season to season, largely according to size of crop.

During the last 20 years the grower was apparently justified in holding only when the indicated crop was far below the average, or not much more than 3 bushels per capita. In other years the chance of profit to the grower was too uncertain to balance the added risk, cost, and shrinkage. The grower who acted according to early forecasts, selling at once when heavy yields were indicated, or selling at convenience in case of doubt, and holding only in very scarce seasons, apparently had a chance of being right three out of four times, judging from outcome of recent seasons. (See Fig. 5.)

PRICES IN THE MAKING.

While yield has the most important influence on prices, exceptions have occurred in periods of business depression and unemployment of labor. In such times, potatoes have shared with other commodities the general price depression which accompanies hard times. Accordingly, in trying to fix at long range the probable trend of prices at least three main points must be considered. First, early in the season the increase or decrease of acreage; second, the total supply as indicated by yield, modified by prevalence of rot, disease, or freezing which may reduce the final amount available for marketing; and, third, probable market demand as indicated by business conditions. The situation will be affected somewhat by the indicated amount of competition with imported potatoes and with sweet potatoes. There is also at times competition between the old and new crops which are upon the markets together in April, May, and June.

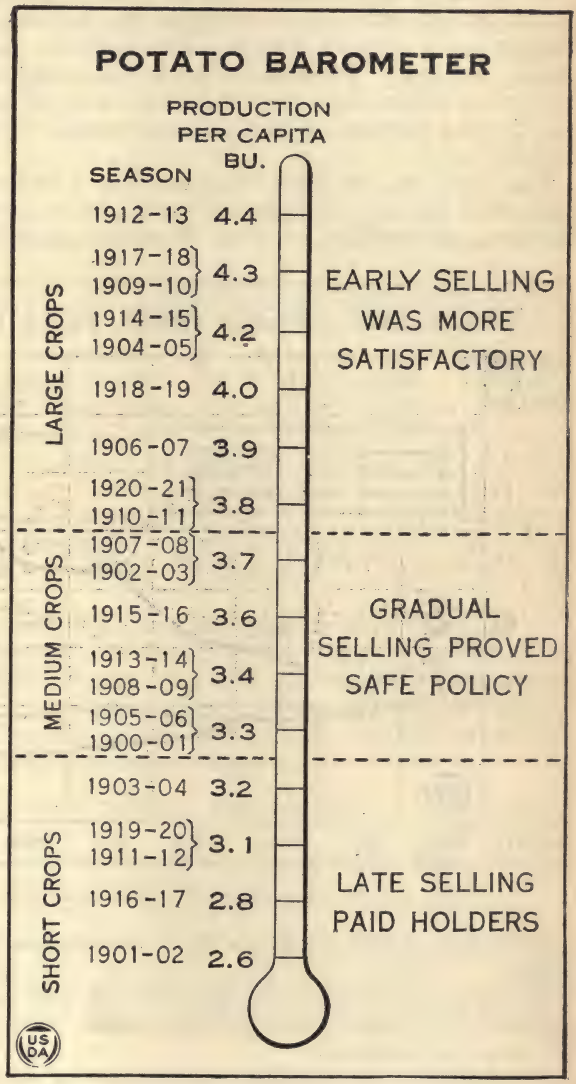

FIG. 5.—Relation of size of crops and selling policy.

Differences in prices in sections of the country are less than they were a few seasons ago when potato prices were far apart even in States located in the same region, like Michigan and Wisconsin. In the 1919–20 and 1920–21 seasons 25 cents per 100 pounds would often cover fairly well the day's differences in prices of potatoes between the principal sections, East and West. This quick adjustment of values may reduce the old-time activities of speculators, but it improves the position of the average grower, dealer, and consumer. The completeness of the evening-up process depends upon the correct market news reaching everybody concerned.

SOURCES OF CROP AND MARKET NEWS.

The daily market news reports of the Bureau of Agricultural Economics are of value in many ways. The buyer as well as the grower shipping his own stock, should note the daily reports of potato shipments so as to forecast the supplies on the market. The shipping-point news supplies information on prices paid in competing sections. Prices in the city markets should be followed to determine when and where shipments should be sent for best returns, and for the purpose of checking up returns reported on sales already made.

The daily reports are summarized in a series of weekly summaries prepared for the newspapers and farm periodicals. For many farmers, the earliest reports of potato crop production, condition, and market prices are from these summaries, published in the local paper.

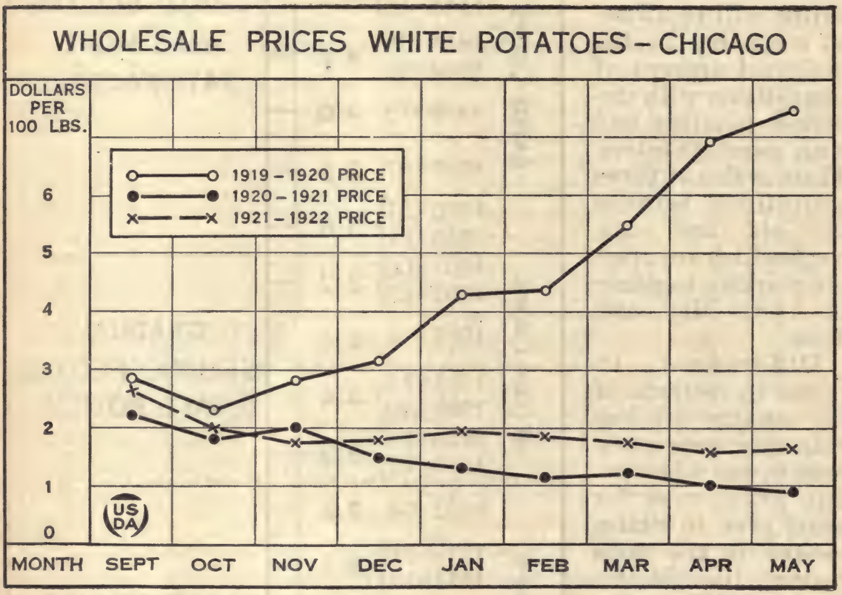

FIG. 6.—Wholesale prices of potatoes in Chicago, 1919 to 1922.

Daily price reports on potatoes are sent out by the Bureau of Agricultural Economics in cooperation with more than 80 radio broadcasting stations.

This service is available at present in 36 States to all persons having receiving sets. Some large producers and dealers or associations receive reports by telephone or telegraph direct from field stations.

A weekly publication of the Department of Agriculture at Washington, called Weather, Crops and Markets, contains important potato crop and market information, including weekly market articles and the crop reports and estimates; all similar to the material published in the daily and weekly reports. This paper may be had at $1 per year of the Superintendent of Documents, Government Printing Office, Washington, D. C.

The other daily and weekly publications, including the potato crop forecasts, estimates, and reports, and the semimonthly crop notes issued about the 5th and 20th of each month showing the important changes in conditions affecting the crop, are sent free on request. Similar reports covering individual States in some detail are published by the agricultural departments at various State capitals.

The field stations from which shipping-point news is sent from the late-potato sections are: Waupaca, Wis., Grand Rapids, Mich., Minneapolis, Minn., Greeley, Colo., Idaho Falls, Idaho, Alliance, Nebr., Rochester, N. Y., and Presque Isle, Me. These stations open from the middle of September to the first of October and close early in April. Daily reports are sent out from the field stations during the season of operation and may be obtained on application to the Washington office or by applying about September 1 directly to the nearest field station. The market stations of the United States Department of Agriculture at New York, Philadelphia, Boston, Washington, Pittsburgh, Cincinnati, Chicago, St. Louis, Kansas City, Fort Worth, Minneapolis, and Los Angeles send out daily potato market reports of country wide scope throughout the year. They include the number of car-lot shipments and where from, the number of cars arriving at the principal cities, the prevailing range of prices or sales by receivers to jobbers or direct to retailers, the quality and condition of receipts, and the market and weather conditions.

Addresses of city dealers who handle large quantities of main-crop potatoes may be had from the market stations or from the department at Washington. The financial and business standing of any dealer may be investigated through the commercial credit books, through the local banks, or through special references which the dealer should be glad to supply on request.

USING THE PRICE RECORDS.

Farmers should keep the various reports together by crops, weeks, months, and shipping seasons, including tables, estimates, summaries, and car-lot statements received. These will be useful for reference, but the main-crop outline should be kept in mind, including production, quality, general market movement, and price range in recent seasons. With these as a background, the prices in leading markets and at shipping points will show which way the general market is going.

Prices are settled mainly where there is greatest sustained volume of sales. The larger markets are first to show the changes in price trend because of their constant activity and frequent sales of large lots. Their huge demands on available stock make them both indicators and regulators of prices.

WATCH LEADING LINES AND GRADES.

The leading varieties and grades sold in the big markets indicate the course of potato prices because they are always in steady demand and are salable in large quantities.

An occasional glance early in the season at quotations of No. 1 Florida Spaulding Rose in New York, or No. 1 Texas Bliss Triumph in Chicago, or, later, the Virginia and Kaw Valley Cobbler in New York, Pittsburgh, Chicago, and Kansas City will give a sufficient idea of the early market to a person interested chiefly in its relation to the main crop, for as the early crop is only about one-fifth of the total production and is not suitable for storage, it seems to have comparatively little effect on the price of the following main crop.

The intermediate crop from New Jersey, Idaho, Kansas, Nebraska, Minnesota, etc., competes to a certain degree with the early sales of the main crop and is worth watching, as foreshadowing to some extent the early price of the main crop. Prominent features of the mid-season markets are the New Jersey Giant and Cobbler in New York and the Minnesota Early Ohio in Chicago and Minneapolis.

From October onward the late crop holds the market and the prominent lines are Wisconsin, Minnesota, and Michigan No. 1 round whites, and the Colorado and Idaho round whites in Chicago and other great western markets; New York No. 1 round whites in New York; and the Maine Green Mountain in New York and Boston.

LEARNING BY USING.

Expertness in market judgment may be gained only by practice day after day and season after season. One soon learns to look for certain price changes under given conditions. Thus, a long-continued rise is often followed by dullness and hesitation at the top, then a sharp decline, and finally a partial recovery. Declining prices usually occur as shipments reach height, with a recovery and advance after the height of the movement is over. When active buying demand is reported in leading markets after long decline and dullness, a sharp rise often follows. A city quoting high prices may soon quote lowest on the list because of the large supplies likely to be diverted to that market, but cities having no large neighboring supply may quote higher prices than other markets for a considerable time when car-lot arrivals are light.

Extreme weather, either hot, cold, or stormy, may interfere with quantity or quality of supplies and cause active but short-lived fluctuations in price, and so with scores of price movements in which the reader of market reports soon becomes well versed in connection with the markets in which he is interested.

The practiced reader glances over the daily report, noting which markets show changes in price and the reason why as indicated by what the report says about the supply and demand, the number of cars on track, and the number reported shipped from States supplying these markets. He attaches most importance to changes in leading markets like Chicago and New York. He glances over the shipping-point news at Waupaca, Greeley, Rochester, or Presque Isle to see how country prices and conditions compare with changes in the corresponding city markets.

He goes over the underlying conditions with the aid of the car-lot summary, weekly reviews, and special articles, if the main facts are not already in mind. He notes the size of the crop and the amount shipped from each State for the season to date. He observes carefully the attitude of growers, buyers, and shippers; whether anxious to trade or holding back. He takes into account the supply of empty cars, whether abundant or if shortage exists, and the weather conditions, whether favorable for rapid and safe transportation or the opposite. If the new southern crop is about ready or beginning to compete, he takes that into account—its size, condition, quality, and location—and last, having the situation in mind in all its essential aspects, he forms his own judgment of the probable course of the market.

In general, the man who keeps the main facts in mind and who learns to read the meaning of prices almost at a glance has a definite advantage in buying or selling. The larger the number who are well informed on prices and conditions, the more uniform will prices tend to become in all sections and throughout the season, because all buying, selling, or holding based on knowledge of actual conditions tends to equalize prices and thus in the long run to benefit all. When many thousands of sellers and buyers are equally well informed, there is little opportunity for a few to gain undue advantage.

THE USUAL COURSE OF THE MARKET.

The long range, general behavior of the potato market is much like that for other staple fruits and vegetables which have a shipping season continuing throughout the winter. There is usually a time of low prices during the main harvesting seson, followed by more or less recovery, lasting perhaps until near the end of the calendar year. Then comes an irregular course throughout the winter, depending partly on conditions of weather and transportation, and finally a new movement in the spring either up or down, according to the supply on hand when hauling and shipping conditions are favorable and the active late movement begins.

WINTER TREND UNCERTAIN.

Aside from two or three of the war-time years, the chances of rise or decline between fall and spring appear about equal. Of the 11 years 1910 to 1920, inclusive, five have shown losses and six have shown gains. The only pre-war season of the series showing a great advance was the one following the very short crop of 1911, when the gain was $1.28 per 100 pounds between October and March. In 1919–20 old potatoes advanced nearly $3 per 100 pounds from October to March. This gain alone raises the average nearly 30 cents for the 11-year series.

Declines have been less extreme than the two or three spectacular advances. The great decline of 60 cents in the 1920–21 season was exceeded only in the record crop season of 1917–18, when the price dropped 88 cents from October to March. The decline during the third largest crop season, that of 1912–13, was 29 cents during the six months. Taking the five principal war-time seasons by themselves, the average gain was 26 cents from October to April, but three of the five seasons show declines. The relation between production and prices is notable throughout.

DEALERS' HOLDINGS.

An estimate of the proportion of potato stocks held by dealers the first of the year is included in the official report of January stock on hand.

Apparently nearly half of the dealers' holdings are in possession of wholesalers, over one-third are held by retailers, while about one-sixth are in warehouses and miscellaneous storage, as shown in Figure 7.

The extent of dealers' holdings shows in general their real opinion in regard to the future of the market. It appears that in many instances the dealers' market position thus indicated has been borne out by the course of prices during the last part of the season.

During the period covered by Figure 8 potato prices for the month of March advanced usually as compared with the December price whenever the stocks held by dealers were very much in excess of 20 per cent of the total stocks on January 1. When the stocks held by dealers were very much below 20 per cent of such total stocks, the March prices are shown to have been below the December prices. When the stocks held by dealers were close to 20 per cent, the price trend varied. However, the March prices rose to some extent in all but one or two of these close years.

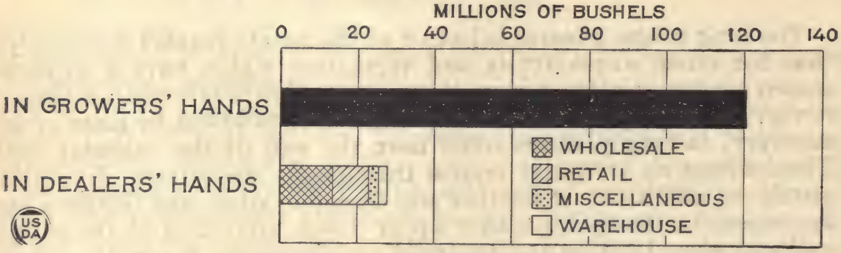

FIG. 7.—Holdings of the January potato stocks. Showing average proportions held by growers and the various classes of dealers. Based on special reports to the United States Department of Agriculture for January 1, 1917, and January 1, 1918.

The practical conclusion is that growers may fairly take into account the plain eagerness or reluctance of long-experienced dealers in buying potatoes during the early part of the season. If they seem glad to buy all they can get at the going prices, they evidently expect the market will go up. If they hold off from buying, a lack of confidence is shown. If the January report shows that the dealers have bought much above or much below 20 per cent of the supply, their feeling as a group shows plainly in the figures. Those indications should help the grower more or less in forming his judgment regarding the best time to sell.

A GLANCE AT RECENT MARKET TREND.

The spring of 1917 witnessed extreme shortage and high prices following the very light crop of 1916, but the large supply of early potatoes brought down the price rapidly and new stock started around $2 per 100 pounds. The estimated main crop of 1917 was the largest on record up to that time. Shipments were heavy after the end of the year. Prices continued generally weak until the middle of March, 1918, reaching $1.25 to $1.80 per 100 pounds in the city markets, then recovering somewhat after the middle of the month.

The 1918–19 season, except for a late spring rise and less irregularity of price range in winter, was in a general way much like the 1917–18 season. There were heavy crops in both years. The general course of the market for the main crop may be illustrated by the jobbing and car-lot prices of Wisconsin and Minnesota stock, which sold in Chicago late in October at $1.75 to $1.90 per 100 pounds and declined to $1.50 to $1.60 in the middle of November, recovered to $1.90 to $2 by January 14, and closed late in June at $1.25 to $1.50. Thus the market during the season showed four leading price movements, all within a relatively narrow range. The low prices reached late in the season were brought about, undoubtedly, by the poor keeping condition of the stock, which rendered it almost unsalable when new potatoes from the South began to arrive.

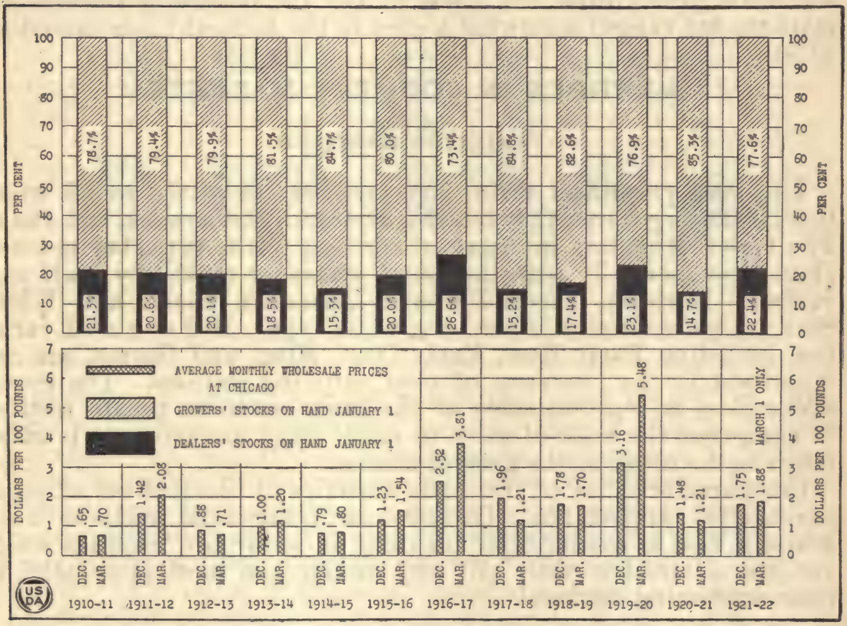

FIG. 8.—Large holdings by dealers and rising winter prices often go together.

With production far above the average, the 1920–21 season opened weak and unsettled, and the price touched $1.50 per 100 pounds at Chicago during September, and recovered to $2.25 in October. Then the price moved slowly downward almost continuously, although recovering slightly in January and again the last of February. Late in April came the season's lowest point, 80 to 90 cents.

The 1921–22 season was exceptional in the fact that prices tended mainly downward, although the crop was estimated below average. Actually the harvested crop was large in some sections. The important shipping States—Maine, Minnesota, North Dakota, Colorado, and Idaho—had a large surplus and the car-lot movement was heavy to the States where shortage existed. Prices were fairly steady the first three months, with the average about $2 per 100 pounds in large shipping markets. In the East prices advanced in January, but after that month the tendency was downward under the pressure of heavy supplies, although at the lowest points, around $1.50 per 100 pounds in the spring, the price was at least 50 per cent above the level at the corresponding time in 1921.

A crop of record-breaking size in 1922–23 was responsible for a generally low level of prices. Production was abundant in practically all important regions and the supply exceeded the demand. Prices paid to farmers ranged, much of the time, as low as 25 cents per 100 pounds in the far West and 75 cents in the East. City wholesale prices often fell below $1 per 100 pounds in midwestern markets, but ranged somewhat higher in the East, at times exceeding $1.50.

METHODS IN COUNTRY MARKETS.

VARIETIES HANDLED.

The most prominent main-crop varieties are of the round white type, including Rural, Cobbler, Russet-Rural, McCormick, and Pearl. The Green Mountain is rather of the long white type, but is often classed commercially with the round whites, or quoted by itself as a variety. Burbank, Russet-Burbank, American Giant, and White Star are more strictly of the long white type. Red or tinted varieties, including Early Rose, Early Ohio, King, and Garnet, are not important in the late crop of most shipping sections. The round white class is representative of the great northern potato section. It comprises the bulk of sales in many large markets and is often taken as the index of the general market.

Comparatively few of the many varieties of potatoes are of much commercial importance. Growers in commercial sections have found it best to confine their planting to one or two varieties which are best adapted to their soil and climate and most in demand in their consuming markets.

SUCCESS DEPENDS ON GRADING.

In the marketing process, the handling of potatoes at the shipping point is plainly one of the main items in deciding how the potatoes from one section shall stand in the consuming market in competition with those from another section. Upon the extent to which growers realize this connection depends the degree of care exercised at the shipping point.

Within the last few years the grading of the crop has come to be considered fundamental to commercial handling. Grading according to accepted specifications checks wasteful and unfair practice between shippers and receivers and is a protection to consumers as to quality and size. Careful grading can prevent many disputes and heavy losses to shippers. Such losses have always reacted to the detriment of growers. By lessening the element of chance grading does much toward reducing the margin that must be allowed between the price paid the grower and the price received by the shipper.

State and Federal cooperative inspection service at shipping points has been established in California, Washington, Montana, Idaho, Utah, North Dakota, South Dakota, Colorado, Missouri, Maine, New Jersey, Wisconsin, New York, and Pennsylvania. Many shipping organizations have their own grades and hire their own inspectors to insure the uniformity of stock shipped under their various marks. Shippers in most sections of the main-crop States have voluntarily adopted the United States standard grades for potatoes, and stock that is not shipped " field run " is graded as U. S. No. 1 or U. S. No. 2, these widely adopted terms having proved especially convenient in quoting. Potatoes shipped " field run " are usually sold as such, but at times adverse market conditions will require them to be graded at the market end before they can be sold.

TABLE 2.—*Tabulated comparison of United States potato grades.*

Grade.	Minimum diameter.	Tolerance for under size.	Tolerance for defects.	Tolerance for soft rot, decay (included in " Tol. for defects").	Frost injury and decay.	Second growth and growth cracks badly misshapen.	Dirt, foreign matter, sunburn, hollow heart, cuts, scab, blight, dry-rot, damage by insects or mechanical means.
	Inches.	*Per cent.*	*Per cent.*	*Per cent.*			
No. 1...	1⅞ (round) 1¾ (long).	5	6	2	Free....	Free............	Free.
No. 2...	1½..........	5	6	2	Free....	No restrictions..	Free from serious damage.

Additional grades not yet extensively used are: U. S. No. 1 Small, which is designed for potatoes from 1½ to 1¾ inches in diameter—the regular No. 1 grade except in size, and U. S. Fancy No. 1, to consist of potatoes of one variety which are mature, well-shaped, free from freezing injury, soft rot, dirt or other foreign matter, sunburn, second growth, growth cracks, hollow heart, cuts, scab, blight, dry-rot, disease, insect or mechanical injury, and other defects. The range in size must be stated in terms of least or greatest thickness or weight following the grade name, but in no case must the diameter be less than 2 inches.

For the main crop as a whole grading in the field is a rare practice. Growers who own graders usually operate them in their barns or storage cellars, the potatoes are stored as dug and are graded as they are hauled to the track. Those who do not have graders must haul their stock to the track and sell at a lower price as " field run " or wait while the buyer runs it over his grader in the car or warehouse, receiving pay for those accepted and hauling the culls back to the farm.

Potatoes graded and sacked on the farm are subjected to much less cutting and bruising than those which, in addition to the initial handling on the farm, are forked into a wagon, then scooped into a warehouse, or perhaps thrown into a car and again scooped to the ends to be shipped in bulk. Too much is expected of the skin of the potatoes, and they are often treated almost like so much coal.

BASES OF SALE.

It is hard to classify the numerous bases of sale on which potatoes change hands in producing sections. At the same shipping point, for instance, one grower may load a car and sell it to a track buyer, or sell it by wire to a city dealer, or consign it to a broker. Another may haul his potatoes to the track and sell to a warehouseman, or to a dealer loading a car, who may have his market connections or may resell it at the shipping point. Still another may sell his crop " in the dirt " before it is matured, to a dealer who will dig, sack, and resell it before it is shipped.

But it is possible to make some statement as to the prevailing basis of the final transaction in the various shipping sections. As a rule, in well-established commercial districts that ship a dependable grade, dealers make most of their sales by wire on a delivered basis or " f. o. b. usual terms," the price being agreed upon before shipment, but inspection for grade being allowed at destination before acceptance. The " cash-track " basis prevails mostly in sections where the grade is not certain, but sales on this basis are made in other sections when the demand is particularly active.

As a rule, there is a difference of from 15 to 30 cents per 100 pounds between these two basis of sale at any given shipping point, the advantage being allowed to the cash buyer, who assumes ownership and responsibility for the shipment at the point of origin. Consignment is often resorted to in districts where strong associations have permanent market connections or whenever the uncertain market with poor demand and the perishable nature of the stock are important factors.

BULK STOCK OFTEN HIGHER THAN SACKED.

Minnesota, Michigan, and Wisconsin stock on the Chicago market is often quoted from 5 to 20 cents higher per 100 pounds in bulk than it is in sacks, notwithstanding the fact that sacks cost during the last few years from 6 to 18 cents each. The reason is that when buying on the " car-lot outweight " basis of sale, the receiver can see what he is getting. He is permitted to sort out the poor potatoes, paying only for what he hauls over the scales. The culls may be a total loss, but sometimes are sold for about one-third the price paid for No. 1 potatoes. Resorting of sacked stock is rarely allowed, and for this reason it is commonly understood that bulk potatoes from the North Central States are more carefully graded at the shipping point than those in sacks.

Some dealers prefer bulk to sacked stock, as they have a select trade and can not be sure of satisfying their trade unless the stock is sacked under their own supervision. Of course, if shippers always put up good sacked stock it would be only a question of time before there would be no demand for potatoes in bulk. It is but reasonable to suppose that if the buyer could get what he wants in sacked stock he would not go to the expense of putting up bulk stock in sacks, as the cost per car outside of sacks will average around $35.

During a period of dull market conditions, bulk stock may take a position much different from that occupied on a steady or firm market. Buyers then are more disposed to cull heavily and sellers are less inclined to object to heavy culling. It is understood that bulk cars have shrunk as much as 5,000 pounds by culling, whereas in sacks there is no such loss. Not many cars of potatoes in bulk, however, show such shrinkage. In fact, many cars of bulk stock are unloaded with no culls in evidence when the unloading is completed. The difference is merely that in the case of the heavy shrinkages the shipper put his culls in the car and paid the freight, only to have them dumped out upon arrival, while the more careful and experienced shipper took out the culls before loading.

It should be borne in mind that cars of bulk stock are frequently held on the team track at the terminal market from one to two days longer than cars of sacked potatoes because of the time required for sacking the stock. This frequently creates demurrage charges, which must be taken into account in arriving at the net returns from the two classes of stock.

Members of the city potato trade express the opinion that it would be to the general interest of the industry if shippers would put up sacked stock, but qualify this statement by saying that sacked stock should not contain potatoes that ordinarily would be thrown out as culls from a car of bulk. It is believed that if the shipper would sort and pack consistently by established grades, the trade would soon come to know that by examining a few sacks the general quality and condition could be determined and they would be assured of getting better stock than is now generally shipped in sacks.

SACKS IN USE.

Organized shippers in most main-crop sections are making greater efforts each year to use only new sacks for their potato shipments. Realizing the value of the appearance of the package, an association in Colorado has made it a rule for all dealers to specify "new bags" or "old bags" when making quotations.

In many shipping sections of the Western and Central States the 120-pound sack is the one in most common use. The 150-pound sack is used in Wisconsin, Minnesota, Michigan, Kentucky, and in most of the Eastern States; but New Jersey and Maine, of the eastern group, use the 165-pound sack. The percentage of the crop shipped in bulk ranges from 10 per cent in Michigan to 40 per cent in Nebraska and even as high as 60 per cent in New York and Maine, and varies with the demands of the consuming market and the availability of containers. The use of 150-pound sacks began in northern Maine in 1921–22.

On account of the high price of new bags in 1919 and 1920 (15 to 18 cents), second-hand bags of every size and description were used at shipping points. Perhaps the best appearing of these was the second-hand wheat bag, common in some of the Western States. This bag, used once for grain, was clean and bright, and held about 120 pounds. The cost was 12 cents. A fertilizer bag holding 100 pounds is a second-hand package commonly used for Maine potatoes in bagging bulk stock at receiving points.

TRANSPORTATION.

Common box cars are used for the main crop marketed in the fall until the carriers require the use of refrigerator or lined box cars. The date of beginning, varying with the sections, is between the first week of October and the first week of November. In 1919 and 1920, the cost of lining a box car with false floor and sides was from $40 to $60, but the shortage of refrigerators made it necessary for a great many shippers to go to this extra expense. The double walls of the refrigerator cars make it safe to ship potatoes in them without a heater, while the temperature stays above zero, but at lower temperatures either an oil "monkey stove" is placed in each ice bunker or a coal stove is installed in the center of the car, as shown in Figure 9. In Maine the carriers supply heated cars for shipments to stations named in advance. These cars are equipped with heaters and oil tanks and the carrier guarantees frost-free delivery of stock shipped in them.

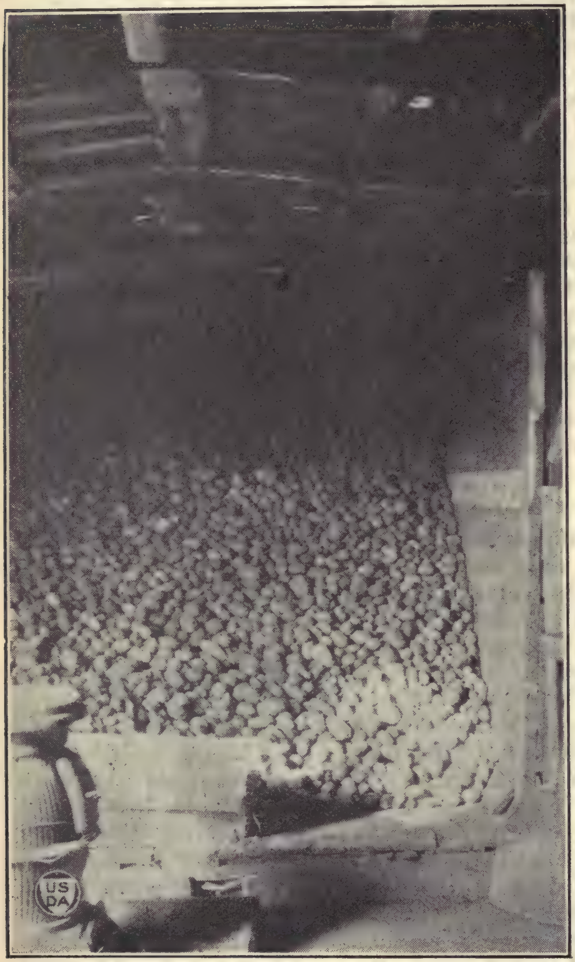

FIG. 9.—A partly loaded car equipped with heater.

The minimum load for unheated cars allowed by carriers varies considerably with different sections. It is usually 30,000 pounds in the South and West, and generally 36,000 pounds in the Central and Eastern sections, but in a few districts is as high as 45,000 pounds, which is the minimum for some types of cars in Maine and Michigan. Most shippers load from 1,000 to 3,000 pounds above the fixed minimum, but the freight charge is based on the fixed minimum in cases where the load falls below it. Heaviest loading is practiced at times of the year when it is neither necessary to ice the cars nor to heat them. Provision for the circulation of cold or warm air requires special systems of loading.

PROMINENT SHIPPING SECTIONS.

Nine regions stand out prominently as important shipping districts for late potatoes: Greeley, Colo., Idaho Falls, Idaho, the Delta Region, Calif., Red River Valley, Minn., Waupaca, Wis., Grand Rapids, Mich., western New York, Allentown, Pa., and Aroostook County, Me. Figure 10 shows the sections in graphic form.

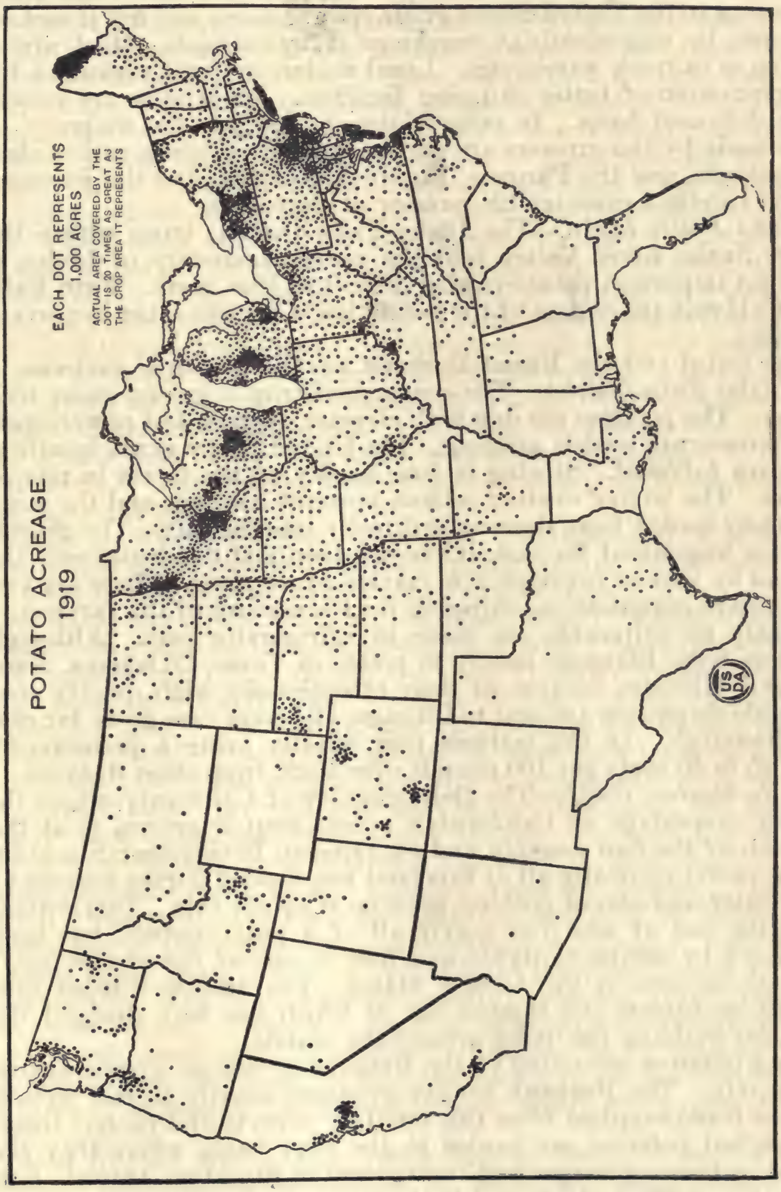
POTATO ACREAGE
1919
EACH DOT REPRESENTS
1,000 ACRES
ACTUAL AREA COVERED BY THE DOT IS 20 TIMES AS GREAT AS THE CROP AREA IT REPRESENTS
US DA

FIG. 10.—Principal potato-producing sections indicated by potato acreage.

Greeley, Colo.—The territory in Weld, Larimer, and Adams counties, centering around Greeley is the most important potato district in Colorado, shipping about 50 per cent of the movement from that State. The San Luis Valley and the Western Slope are two other important districts of the State.

A large part of the Greeley district is irrigated land. The Early Ohio is raised in a small way for an early crop; the Rural and Pearl varieties make up the main crop. The growers sort their stock according to the United States grade specifications and sell it sacked, for cash, by wagonloads at warehouse or by carloads. Most winter storing is in track warehouses. Local dealers are well organized for the promotion of better shipping facilities. Their sales are mostly on a delivered basis. In other Colorado districts the majority of sales made by the growers are on the basis of carloads, rather than wagonloads, and the Farmers' Equity Association and the Farmers' Union handle a considerable number of shipments.

Idaho Falls, Idaho.—The Idaho Falls district, lying within the upper Snake River Valley near the eastern boundary of Idaho, is the most important potato-raising district of that State. Twin Falls and Caldwell are centers of the potato trade for two other important districts.

The Rural and the Russet-Burbank are the principal varieties in the Idaho Falls district. The commercial crop is grown under irrigation. The potatoes are dug with elevator diggers, and power-operated screens are used in grading. The United States grade specifications are followed. Storing is done mostly on the farms in pits or cellars. The winter weather seldom prevents hauling, and the stock is usually loaded from the wagon directly into the cars. The grower sells his wagonload for cash at the car door, and the dealer sells the carload by wire or consigns it to market connections. There are two cooperative organizations shipping for the account of the farmers.

Nearly all shipments are made in refrigerator cars. Although potatoes from Idaho go mostly to points in Texas, Oklahoma, Kansas, and Missouri, because of their exceptionally high quality considerable shipments are sent to Chicago, and some cars go as far east as Pittsburgh. In the markets they usually bring a premium of from 25 to 50 cents per 100 pounds over stock from other districts.

Delta Region, Calif.—The Delta country of California, where the greater precentage of California's potato crop is grown, is at the junction of the San Joaquin and Sacramento Rivers near Stockton. In the past, practically all of this land was flooded during periods of high water and almost nothing grew on it except tule. This bottom land, the soil of which is nearly all of a peaty nature, has been reclaimed by means of dykes and now is one of the richest agricultural sections in the United States. The area is divided into islands by bayous and sloughs out of which has been dredged the earth for building the dykes around the islands.

Long potatoes belonging to the Burbank group are grown almost exclusively. The Burbank variety produces heavily in this section and the trade supplied from this territory expects and prefers them. The sacked potatoes are hauled to the river bank, where they are placed on boats or barges and transported to Stockton, Antioch, San Francisco, or other places, and loaded into cars for shipment.

Growers sell their potatoes by the sack, delivered at the river bank. While the sacks are not even weights, it is understood that they must contain 116 pounds. The prevailing basis of sale by dealers to the trade is by the 100 pounds.

Delta potatoes are marketed chiefly in San Francisco, Los Angeles, and other California cities, with a small percentage going to Arizona, New Mexico, and Texas. Early in the season a few go to the Northwest.

Red River Valley, Minn.—Moorehead, in Clay County, Minn., is the old business center for the potato industry of the Red River Valley, which extends for nearly 200 miles north and south, including much territory in North Dakota. Ninety per cent of the product of the valley is the Red River Ohio, and the rest is mostly the Irish Cobbler. Unlike the other potato districts of Minnesota, the soil in the Red River Valley is a black loam and produces a particularly fine quality of the Early Ohio variety which has come to be known as the "Red River Ohio." Elevator diggers are used in harvesting and most of the growers have graders on their farms and grade their potatoes either in the field at digging time or in their storehouses before they are hauled to the track. United States grade specifications are followed, but much of the stock is shipped "partly graded." From 10 to 25 per cent of the crop is shipped in bulk. Normally a large part of the crop shipped in the fall is bought from the growers for cash at track by wagonload or carload, but during the winter most of it is sold to warehousemen, who make their sales "f. o. b. usual terms." The Chicago market is the controlling factor in the shipping-point price.

Waupaca, Wis.—Waupaca, Waushara, Portage, and Marathon Counties form the heaviest potato-shipping district of Wisconsin. The town of Waupaca is headquarters for the trade.

The Rural and Green Mountain varieties, termed "round whites" by the trade, make up the commercial table crop. A comparatively small acreage is given to raising the Bliss Triumph, Irish Cobbler, Early Rose, and Early Ohio varieties for seed stock. Elevator diggers are used in harvesting, and the potatoes are picked from the field by hand. Such combinations as have been tried thus far of machine picker and digger have proved unsuccessful. Most of the growers store their potatoes field-run on the farm, but many store in track warehouses belonging to dealers. Virtually the whole crop is sold in bulk by wagonloads for cash at warehouse. The dealers grade the stock as it is unloaded from the wagons. Unless marked "ungraded," the State requires that each sack be tagged to indicate one of the United States grades or the "Badger," which is an extra fancy State grade and practically the same as the U. S. Fancy grade. The State supplies men for shipping point inspection, upon request. Dealers make most sales on a delivered basis. There is one organization shipping for the account of the growers. The Chicago market takes most of the output from the State and the price at Wisconsin points is governed chiefly by the condition of that market.

Grand Rapids, Mich.—The Grand Rapids section is one of the principal potato-shipping regions in Michigan, with Greenville the largest shipping station. The Cadillac section is important, with Tustin and Cadillac as two of its largest shipping points.

The chief varieties raised are the Rural and the Russet-Rural, quoted commercially as "round whites." Machine diggers are used. The United States specifications are followed in grading. Most of the crop is sold in bulk to warehousemen, who sack and grade it, making their sales "f. o. b. usual terms." From 10 to 25 per cent of the shipments are made in bulk. The Michigan Potato Growers' Exchange, a cooperative organization, handles shipments for the growers for a fixed charge per 100 pounds.

Michigan enjoys a convenient distribution of its potatoes because of its location with respect to centers of population. Pittsburgh usually takes the largest number of shipments, and Chicago comes second. Other heavy receivers are Detroit and the Ohio cities.

Western New York.—The potato-growing counties of commercial importance in western New York are Steuben, Allegany, Wyoming, Livingston, Cattaraugus, Ontario, Monroe, and Wayne. Some of the dealers make their headquarters in Rochester, but most of them are located at outside shipping points.

The Rural is the principal variety grown. The other commercial varieties are classed with the Rural as round whites. Elevator diggers are commonly used and the potatoes are picked from the field by hand. There are not as many warehouses in western New York as in the potato districts of Minnesota, Wisconsin, or Michigan. Some dealers buy and store in warehouses, but most storing is done by the growers themselves in cellars on the farms, and as a general rule the crop is "farmer-owned" through the larger part of the season. Growers sell by the bushel rather than on the 100-pound basis. The crop is hauled field-run and graded by the dealers according to United States grade specifications. The majority of sales are made by wire on a delivered basis. Most of the early shipments move in bulk, but during cold weather 150-pound sacks are used. The crop is all marketed east of the Mississippi River, the heaviest receivers being New York City, Philadelphia, Baltimore, Pittsburgh, and Newark.

Allentown, Pa.—In Lehigh County the potato industry is more concentrated than in any other district of Pennsylvania. This county forms the center of the most important producing region of the State, which includes all of Lehigh County and parts of Northampton, Carbon, Schuylkill, and Berks Counties.

The commercial crop of this district is 90 per cent Rurals and the rest Irish Cobblers. Practically all the stock is put over grading machines either at the farm or at the cars when being loaded. Most of the potatoes are shipped in bulk, but a few growers put them up in sacks of 100 to 150 pounds.

The greater part of the sales in the district are made to local buyers on a basis of cash to growers at country loading points. Usually the sales are made at a price per bushel in bulk. A few traveling buyers operate throughout the district, but their tonnage is small. The Farmers' Exchange handles a considerable number of shipments. In the region of Macungie, most shipments are consigned to commission houses in Philadelphia. Because of the more careful grading practiced there, that locality has made for its potatoes, a reputation which brings the growers a premium over other potatoes sold in Philadelphia.

Most shipments from the district as a whole go to Philadelphia. Other important markets are New York City and Pittsburgh.

Aroostook County, Me.—The leading potato district of Maine lies mostly within Aroostook County. The most important shipping points are Caribou, Presque Isle, Fort Fairfield, and Houlton.

The Green Mountain, Irish Cobbler, and Spaulding Rose are the principal varieties raised for table stock. Maine growers also raise a large amount of seed stock, of which the Green Mountain, Irish Cobbler, Spaulding Rose, Bliss Triumph, and Aroostook County Prize are the important varieties. The last two kinds are grown mostly in the northern part of the county. The Irish Cobbler seed goes mostly to the South Atlantic potato States, the Spaulding Rose goes to Florida, and the Aroostook County Prize goes to New Jersey, where it is called the American Giant.

Machine diggers are used, and the potatoes are picked from the field into baskets and then dumped into barrels. Most storing is in cellars on the farms. The stock is usually graded over a hand "rack" and hauled to the track warehouses in barrels and sold by barrel measure (165 pounds) rather than by weight. There are several starch factories in the county which buy the culls. They buy the No. 2's as well when there is no demand for them as table stock, paying one-third to one-half the market price for No. 1's. A large percentage of the shipments is in bulk to be sold at city ware-

TABLE 3.—*Outline of prominent late-potato shipping districts.*

State or district.	Representative shipping center (field station).	Season opens.	Season ends.	Principal varieties.	How put up.	Principal consuming territory.
Colorado	Carbondale, Greeley, Monte Vista, Montrose, Delta.	Aug. 1	June 30	Rural, Pearl, Russet-Burbank, Early Ohio.	120-pound sacks.	Colorado, Texas, Arizona, New Mexico.
Idaho	Caldwell, Idaho Falls.	Aug. 1, Sept. 1.	...do...	Rural, Russet-Burbank.	...do...	Texas, Oklahoma, Kansas, Missouri
California	Stockton	June 1	May 31	Burbank	116–120 pound sacks.	California, Texas, Arizona, New Mexico.
Washington	Yakima	Sept. 1	June 30	Russet-Burbank.	120-pound sacks.	Pacific Northwest.
Wisconsin	Waupaca	Aug. 1	...do...	Rural, Green Mountain.	Bulk and 150-pound sacks.	Chicago, Middle West.
Minnesota	Moorehead, Minneapolis.	...do...	...do...	Early Ohio, Rural.	Bulk, 120-pound, 150 pound sacks.	Do.
Michigan	Grand Rapids, Cadillac.	Aug. 15	...do...	Rural, Russet-Rural.	Bulk and 150-pound sacks.	Pittsburgh, Chicago, Middle West.
Nebraska	Alliance	Sept. 1	May 31	Early Ohio	Bulk and 100-pound sacks.	Nebraska, Missouri, Kansas, South Dakota.
New Jersey (north).	Freehold	Aug. 1	...do...	American Giant, Green Mountain.	Bulk, 150-pound, 165-pound sacks.	Pennsylvania, New York, New Jersey, Ohio.
Pennsylvania	Allentown	...do...	June 30	Rural	Bulk, 100-pound, 150-pound sacks.	Philadelphia, New York, Pittsburgh.
Western New York.	Rochester	Sept. 1	July 15	...do...	Bulk and 150-pound sacks.	New York and other eastern markets.
Maine	Presque Isle	Sept. 15	June 30	Green Mountain, Irish Cobbler.	Bulk, 150-pound, 165-pound sacks.	Boston, New England, New York.

houses or sacked there. Sales of Maine stock on the Boston market are mostly in 100-pound sacks, which are put up in the receiving yards near the city. At New York City it is sold on a 180-pound bulk basis or in 150 and 165 pound sacks. Most of the business is transacted on a delivered basis. The size of the New Jersey crop is an important factor in making the price of the fall shipments from Maine. Boston is by far the heaviest receiver of Maine table stock, and New York is next in importance. Other important markets are the New England and Atlantic Coast cities. (See Table 3.)

MARKET PRACTICE AT A NORTHERN SHIPPING POINT.

A description of what takes place during an average day in the potato season at the important shipping point of Waupaca, Wis., will give an idea of the activities at most of the shipping points in the Northern States.

At any of the established northern shipping points during times of moderate or slow demand the price depends upon the condition of the market most important to the district in question, and upon the size of the movement the day before. The volume of inquiry as indicating market tone is also considered. Each morning from 10 to 25 dealers at Waupaca and points within a radius of 50 miles call up the Waupaca office of the Bureau of Agricultural Economics. They get the Chicago market information as soon as it comes over the wire, and the number of cars shipped the previous day for the country as a whole and from the important Northern States separately. On this information they form an idea of the supplies for their principal markets. The probable price is then estimated, the basis being approximately the Chicago market less the freight and the dealer's margin for handling. As a rule, the dealer's margin is narrower in the fall than in the winter months because of the lower expense of handling immediately and shipping without heating, and because the stock held for spring shipment must be carried and stored for several months. Competition among resident dealers and track buyers during the fall months also tends toward a narrower margin by raising the growers' price.

Growers must haul from 5 to 15 miles. Because of the risk of freezing at night it is the general practice to load the wagons in the morning, and the loads begin to arrive at the track about 9 a. m. Normally there is very little bidding for loads at Waupaca, but the established dealers have their lists of growers who haul to them regularly. The load is weighed on a wagon scale. A few growers haul in sacks to prevent bruising the stock, but practically no grading is done on the farms, and the sacks are emptied at the warehouse. One of these is shown in Figure 11. The potatoes are unloaded into a chute or upon a belt which carries them to a power-operated screen. The culls (and the No. 2's if the dealer is not buying No. 2's) are loaded into the wagon again, which is then weighed a second time to get the net weight of the potatoes accepted. If the grower is merely storing with the dealer, he gets a receipt for his load; if he is selling, he gets cash.

In the better-equipped warehouses the potatoes, after being graded, are carried to overhead distributing runways, which may be adjusted to drop them into any one of the various storage bins. If it is the intention to hold the potatoes for some time, they are stored in bulk, as shrinkage and possible decay of some of the tubers make it impracticable to keep them long in sacks. Before shipping, sacked potatoes are tagged according to grade. For bulk shipments the grade must be stated on the invoice.

Virtually all cars handled by the resident dealers are loaded by their own men, as they prefer to do this rather than to depend upon the growers' comparatively limited experience in grading and packing. In freezing weather refrigerator cars are used for shipping, because of the protection afforded by their double walls. When there is a shortage of that equipment, some shippers use box cars fitted with a false floor and lined with lumber and building paper.

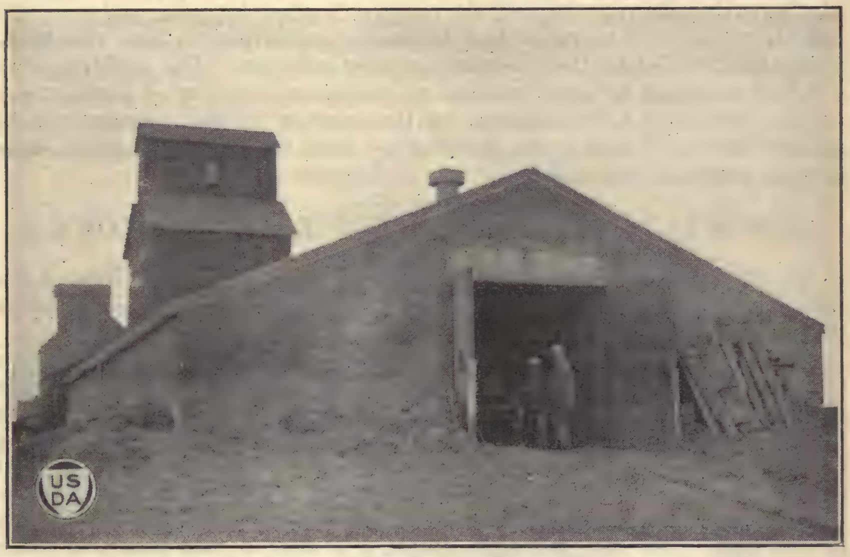

Fig. 11.—A track warehouse in the Great Lakes region.

There are two arrangements for the protection of potato shipments between October 15 and April 15 on all roads west of Chicago. These arrangements are termed "shippers' protective service" and "carriers' protective service." Under "shippers' protective service" the charge, in addition to the freight rate, is only $5 for the use of the refrigerator car. The railroad allows free transportation for a caretaker, or stoker, to the destination and back, and any lining or stoves used in the car are returned to the shipper at half rate. No guarantee of frost-free delivery is made. Under "carriers' protective service" the charge, in addition to the freight rate, is $12 to $18 per car, depending upon destination, and amounts to 4 to 6 cents per 100 pounds for the average haul. The railroad guarantees frost-free delivery. Usually an oil heater is placed in each bunker. The employee in charge is instructed to close the vents when temperature reaches 32° F., start one heater at 20° F., and both heaters at zero.

Sales are made mostly by wire. When the market is strong and buyers eager to get potatoes the usual message is one asking the shipper to quote on a given variety f. o. b. or delivered at destination. The shipper quotes, and, if the other party confirms the price, the sale is considered closed and the car is shipped as directed, the telegram being kept as a record of the sale. When the market is dull and sales slow, many shippers wire to a number of their trade connections, usually by night letter, offering a list of quotations. If the trade "comes back" the following morning, the shipper confirms the quotation in question and the sale is closed.

It is a common sight, especially in times of slow movement, to see several representatives of different railroads visiting the shippers of the town, soliciting business for their respective companies. Most of the railroads represented do not touch the shipping point itself, but they may get more or less business, according to how the shipments are routed to their respective destinations. The difference in any two routings to one destination is largely a matter of promptness of delivery and of treatment by the carrier in the adjustment of claims, the tariff to a given destination over one road being the same as over another, regardless of any difference in distance.

COUNTRY MARKETS IN WESTERN NEW YORK.

The day's program in the shipping section in western New York near Rochester is representative in a general way of the operations in the eastern potato country.

While Rochester itself is not a shipping point, it is considered a center of the potato trade for western New York and is centrally located with reference to the principal producing areas. Monroe County, which includes Rochester, is the largest potato-producing county in the section. Some of the largest dealers are located in that city. In the office of a dealer who handles at least three to five carloads a day, telegrams and price inquiries are being received early in the day. So far, perhaps, inquiry is active and business looks promising. Long-distance calls are coming in from points to which he ships, and it is reported that supplies are light, the demand increasing, and market firm with prices advancing slightly. Apparently a general price advance may occur.

However, not the least important consideration at the time is the number of cars being shipped to markets that draw supplies from this section and the total movement from each competitive area. If these other regions are shipping heavily, the market will bear close scrutiny. The local representative of the Bureau of Agricultural Economics is called and information is obtained as to movement and destination on the previous day. The dealer concludes that supplies in the city markets are light, shipments are light, and there is an increasing demand and inquiry. His asking price is advanced and wire "feelers" are sent out to prospective customers.

If he is able to secure the advanced price and the market seems likely to hold strong for a few days, he telephones his buyers who are located in one or another of the principal producing areas, informing them as to the price per bushel to offer the growers. The cost of sacks, labor, material for loading the car, plus a certain profit, is included in the buying price. In this section there seems to be much competition between the different buyers in the same town. Immediate necessity for stock required to complete orders, or for speculative purposes, often makes it possible for the grower to secure a premium for his potatoes.

Orders by telegraph comprise the bulk of sales by the dealers. Inquiries usually ask for a quotation on sacks or bulk f. o. b. destination. However, a few sales are made on the basis of 100-pound or 150-pound sacks f. o. b. shipping point. It has been found more satisfactory to quote prices per sack delivered or "f. o. b. usual terms." The dealer wires his price in response to the inquiry, and if the offer is accepted the deal is considered closed. Collection is usually made by means of bank draft. Some few shippers who deal with houses of long-established reputation or who trust to the honesty of receivers, ship "open" and receive returns through ordinary methods. Many of the dealers who handle potatoes also deal in other commodities, and in this way the expense for telephone and telegraph service is not chargeable in full to the one crop, and the expense incurred in securing information is considered well spent. The smaller dealers usually depend on price information and use as their gauge the official "Daily Market Reports" and the volume of letters or wires received. They strengthen their attitude whenever the inquiry becomes heavy and hold their stocks for all the market will bear.

The buyer has a warehouse and office usually on a railroad siding with facilities and machinery for grading and sorting. He does business by telephone with certain growers with whose stock he is familiar. News of any advance or decline in price travels swiftly; and if the growers are disposed to sell, haulings begin immediately. Prices to growers in a normal season remain fairly steady; for on an average changes are made not oftener than once a week.

If the stock has been already inspected by the buyer and terms arranged, the bulk potatoes are hauled to the warehouse, weighed, graded and sacked, and loaded aboard a car. Refrigerator or protected cars only are used during the cool months, and papering of the ordinary car is necessary.

Very few dealers in this section seem willing to let the growers do the grading and sorting. They claim that experience has taught them it is better to do this work carefully and by improved methods and machinery than to trust to the grower. Few growers have either the machinery or the lighting facilities to insure a good pack. Much trouble is experienced because many growers do the packing under such conditions that they are not able to inspect the potatoes closely and do not put up a reliable pack. While undoubtedely some cars are rejected at destinations for other causes, it is probable that most rejections are the direct result of poor grading.

In a season of heavy production dealers generally make no effort to store potatoes for even a short period; it is merely a case of hauling as the needs of the day's business demand. In such a season no buyer is willing to buy any reserve stock because the market, although fluctuating from week to week, is often on the downward grade.

A GLIMPSE OF CITY MARKETS.

As a rule city markets draw their main crop supplies mostly from the nearest large producing sections. Chicago and other midwestern cities receive potatoes chiefly from the Great Lakes region; eastern cities mostly from Maine, New York, New Jersey, and Pennsylvania; southern cities from the State due north; far western cities from the Intermountain region and Pacific coast shipping points. But in seasons of shortage Maine potatoes may go far west and south, or potatoes from Colorado and Idaho or from Washington may go to California or to eastern consuming sections. The source of supply of the chief cities is shown in Table 4.

TABLE 4.—*Main-crop car-lot potato supplies of cities.*

Cities.	Average number unloads per year five-year average.	Origin of late car-lot supply.	Per cent of potato supply received from late-shipping sections.	Leading varieties or types main-crop receipts.
Boston	[1] 8,277	Maine, New Brunswick	79.8	Maine Green Mountain Cobbler.
Buffalo	[1] 1,710	New, York Michigan, Maine	48.9	Round white.
Chicago	8,924	Wisconsin, Minnesota, Michigan, Idaho.	75.7	Round white, Russet, King, Burbank.
Cincinnati	1,395	Michigan, Minnesota, Wisconsin.	66.7	Round white, Red River Ohio.
Cleveland	[1] 1,787	Michigan, New York	57.1	Round and long white.
Columbus	[1] 682	Michigan, Minnesota	69.8	Round white, Early Ohio.
Detroit	1,472	Michigan, Wisconsin, Canada	60.7	Round and long white.
Indianapolis	[1] 1,565	Michigan, Wisconsin	74	Round white.
Kansas City	1,932	Minnesota, Colorado, North Dakota, Nebraska, Idaho.	82.4	Minnesota Red River Ohio, Colorado round white.
Minneapolis	673	Minnesota, Wisconsin, Washington, Canada.	91.1	Round white, Early Ohio, Bliss.
New York City	10,155	Maine, New York	57.7	Round white, Green Mountain.
Omaha	[1] 932	Nebraska, Minnesota	90.1	Early Ohio, Bliss Triumph.
Philadelphia	3,741	Pennsylvania, New York	52.9	Round white, Giant, Cobbler.
Pittsburgh	3,541	Michigan, New York, Wisconsin.	74.7	Irish Cobbler, round white.
St. Louis	2,461	Wisconsin, Colorado, Minnesota, Idaho.	84.9	Round white and long white.
St. Paul	308	Minnesota, Wisconsin, Washington, Canada.	89.8	Round white, Early Ohio, Bliss.
Washington	438	New York, Michigan, Maine, Wisconsin.	46.7	Giant, Green Mountain, round white.

[1] Less than five years.

A great distributing market like Chicago handles more or less stock from opposite ends of the country. It is one of the most active potato markets, and responds quickly to changes in general conditions of supply and demand, often showing earliest signs of coming developments in the trend of the general market. Shipping-point markets tributary to Chicago usually respond to Chicago market changes within 24 to 48 hours. Many sales in the Chicago market are in car lots. About one-fourth of the business is on a commission basis.

It is well to have car lots arrive about the middle of the week, as the accumulated supplies are heavy on Monday, while trading slows down the last part of the week. Sales are made on team tracks of the railroads. The buyer looks over the car, usually looking into a few sacks, if it is sacked stock, or digging down a foot or so if it is bulk. If the car suits, he makes terms with the receiver, gets his sale ticket, brings in his trucks, and unloads the car. Each load is weighed on the railroad scales, and a copy of the scale ticket is given to the seller. Bulk stock is sacked in the car, the culls being sorted out. The buyer pays only for what goes into the sacks. Thus, a car of bulk stock may bring more per 100 pounds, as compared with sacked stock, but less for the car lot, because of the culls thrown out in sacking. The buyers at the car-lot market are mostly jobbers, who resell to such customers as provision dealers, hotels, and peddlers. The scene in the heart of the market district, Figure 12, suggests the activity prevailing in the process of distribution.

The St. Louis market price follows rather closely the market at Chicago, allowing for freight. Car-lot sales may be subject to weighing and sorting, as at Chicago, or they may be transacted at invoice weight but at about 10 cents per 100 pounds less. If sales are to be delivered to buyers, 10 cents extra is charged. Most sales are of sacked stock. Another feature of the St. Louis potato market is the popularity of the 100 or 120 pound sacks, as compared with 150-pound sacks, favored in many middle western markets. Government inspection is often requested either by the seller or the buyer. Inspection certificates frequently forestall a lawsuit.

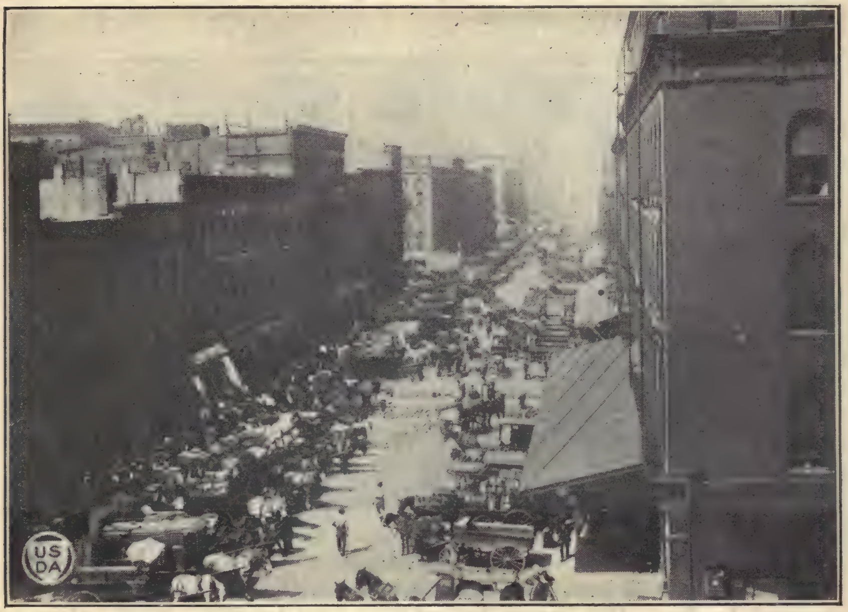

FIG. 12.—South Water Street Market, Chicago.

The Kansas City market seems to prefer northern potatoes rather than western stock. Large quantities of western potatoes, especially from Colorado, are diverted at Kansas City to southern markets. In general, the sales methods are like those of Chicago or St. Louis.

New York is the largest consuming market. It does not reship many car lots, but repacks small lots to supply dealers in near-by towns and cities. Stock from Maine, New York State, and Canada usually sells at about the same price, but there is a decided preference for the Green Mountain variety. New York is a poor market for No. 2 grade. Buyers take away their potatoes, or pay receivers 10 to 15 cents per package for delivery. Sales are mostly from the railroad piers, some of which are shown in Figure 13. Unlike western markets, car-lot prices are the same as for jobbing sales.

Boston's late potato supply is chiefly from Maine and Canada. Nearly three-fourths is bulk stock from Maine and New Brunswick. Sales are made mostly to jobbers in Boston and adjoining cities. The same dealers sell in smaller lots to retailers, charging from 10 to 15 cents a bag more than the wholesale price at the yards in Charlestown. Practically all stock, including Canadian, is sold to conform to the United States grading rules. No. 2 stock is not wanted in the Boston market.

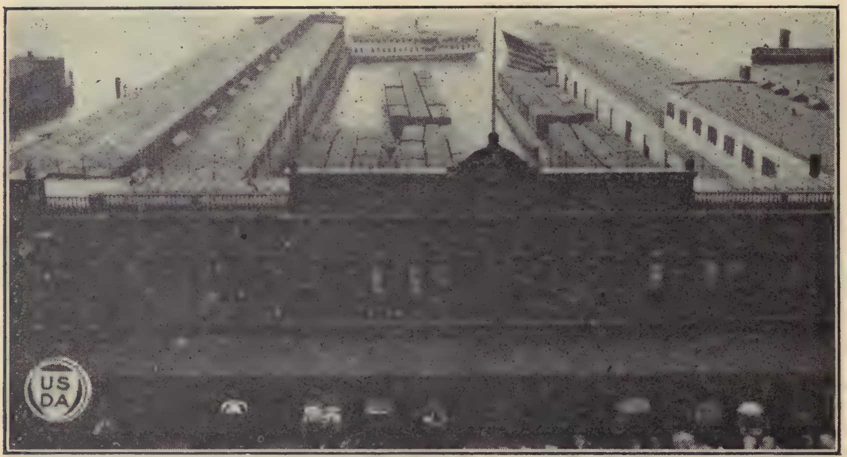

FIG. 13.—Piers along the Hudson where potatoes are unloaded.

Cities located in great producing sections depend much on supplies brought in from the farms by wagons and trucks. Such cities as Minneapolis, St. Paul, Rochester, and Buffalo are shipping centers rather than consuming centers for outside stock. Detroit is largely in this class, as it receives five-sixths of its supply from its own State. It receives practically no stock on consignment.

Most of the large handlers of potatoes in Cincinnati prefer to buy rather than to handle on commission; over four-fifths of the trade is by direct purchase at shipping points. The market prefers the 150-pound sack for white stock and 120-pound sacks for pink-skin potatoes.

The Cleveland market is much like that of Cincinnati, but sometimes pays a little more for good New Jersey or western potatoes than for northern stock, and does not favor dark-colored or semi-russet stock.

Pittsburgh draws much of its winter supply from Michigan, mostly of the round white class. There is little commission trade, and a great deal of stock is reshipped to out-of-town points in large and small lots, thus creating one of the most active of the great city distribution centers as suggested by the illustration (Fig. 14). Omaha has special preference for Minnesota and North Dakota Red River Ohios, and for Idaho Netted Gems. Nebraska stock is now generally sold on grade and is received with increasing favor in this market.

The Washington (D. C.) market buys most of its winter stock through brokers or northern dealers, and takes considerable quantities of New York and northern potatoes.

The " bushel " basket trade in near-by stock is a prominent feature in Baltimore, superseding bushel boxes in that section. The contents of the basket weigh 50 to 56 pounds. Later in the season the round whites from western Maryland and western Pennsylvania are popular for their smoothness and good cooking and keeping qualities. Then come shipments of northern round whites. Most sales are made by receivers or commission dealers in less than carlots.

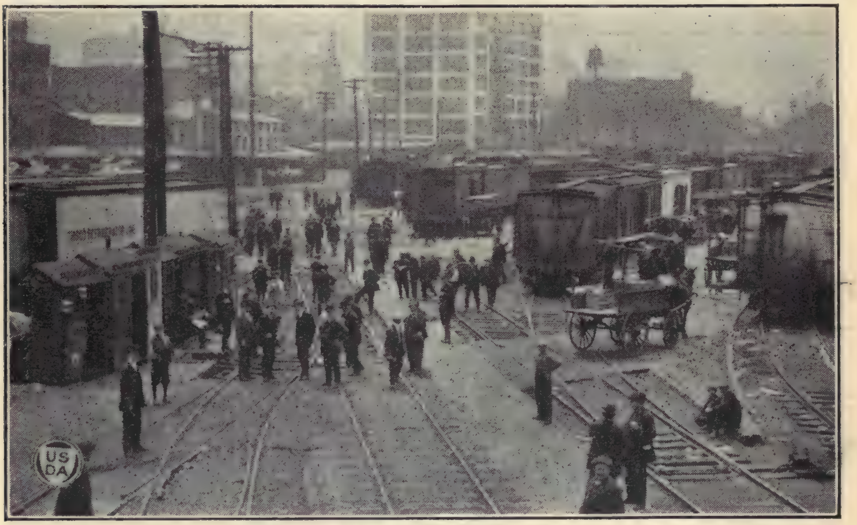

FIG. 14.—Pittsburgh potato market.

In Philadelphia is a distinct class of dealers who handle only main-crop potatoes. Commission is 5 to 8 per cent, or so much per 100 pounds or per bushel. The chain stores are large buyers and some of their buying is direct from country shippers.

Some of the larger cities of the South are fairly active consuming sections for northern or western potatoes. Atlanta takes New Jersey stock in September, but throughout the winter draws from the North and West—sometimes from as far west as California, Colorado, and Idaho. Potatoes should not be consigned to southern cities unless through previous arrangement with the receiver. Such markets are easily oversupplied. Most sales are made through local brokers before the cars are shipped. Northern stock in 150-pound bags is the standard.

The Houston (Tex.) market has been estimated to take 2,000 to 2,500 cars of potatoes from Idaho, Colorado, California, and the Northwest.

New Orleans draws supplies from the North and the Northeast during the fall and winter.

California markets take outside supplies, mostly from Idaho and Oregon. San Francisco is a good hotel market, and there is a heavy demand for fancy grades, obtained by sorting potatoes on the dock or track.

MISTAKES OF SHIPPERS AND RECEIVERS.

Many of the losses to shippers result from poor grading and from careless handling and loading. Many complaints regarding inferior quality of main-crop potatoes come under some of the following heads: Undersize, mixed 1's and 2's, scab, rot, cuts, and bruises.

FIG. 15.—A southern wholesale potato market.

Several of the more troublesome defects are illustrated in Figure 16. Shippers in car lots as a rule lose heavily when a car must be discounted because of freezing injury or inferior quality. They lose not only the potatoes sorted out, but the amount chargeable to freight and the cost of labor in handling such stock.

A mixture of red and white varieties, or even of two types of white stock, is a common source of trouble at unloading points. In Boston, many shipments from Canadian towns contain a mixture of the Cobbler and Green Mountain. Receipts at Chicago from northern producing centers may include car lots of mixed red and white varieties. Such conditions involve a discount in the price, and in times of declining markets are frequently a basis for rejection of cars bought as one variety or type. Packed and loaded separately, either variety might command full price.

Red varieties of main-crop potatoes often sell at a considerable discount. Possibly the reason is that in former years several coarse, watery types of potatoes, red in color, were sold in large quantities. They created a prejudice against the color, although several well-known varieties with pink or red skins are of excellent quality.

In the New York market, Maine sacked stock seems to have a slight preference over sacked stock from New York and New Jersey, owing principally to the varieties shipped from these sections. Several markets show disfavor toward No. 2 potatoes from any section.

Shipments for the middle western markets should be packed in 150-pound sacks in fall and winter, to avoid repacking and the errors in weight and shrinkage resulting from repeated handling. Important shipping sections in northern Maine are now using this pack to a limited extent for eastern markets.

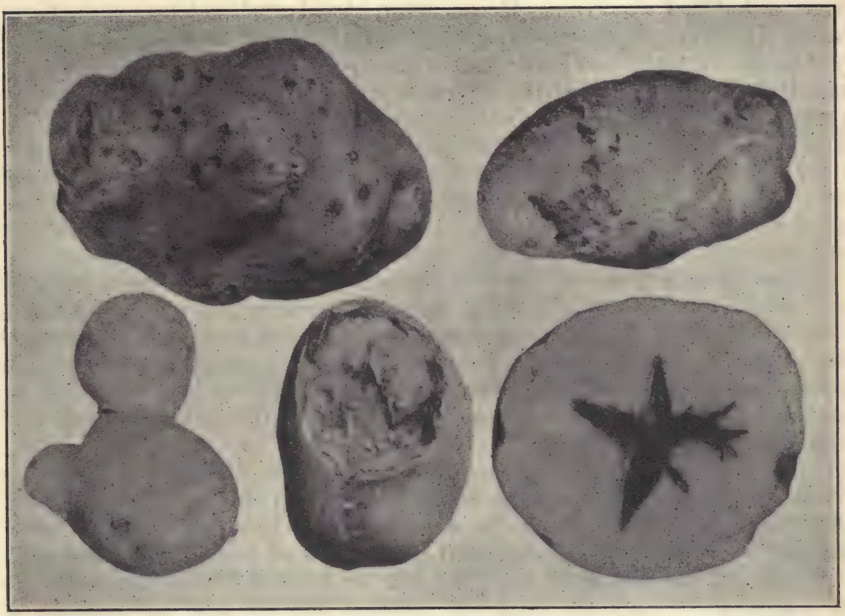

FIG. 16.—Common defects of main-crop stock. Upper row left to right: Wire worm and scab injury. Lower row left to right: Irregular second growth, late blight tuber rot, hollow heart.

A study of freight rates may suggest profitable changes in market destinations. Thus in cities in southern California the excess freight rate from shipping stations in the State of Washington confers an advantage on Idaho shipping points and makes the Idaho stock preferable when offered at the same price in producing sections. In eastern markets similar conditions often give an advantage to stock from near-by producing sections in New York State and Pennsylvania as compared with Maine or the Great Lakes region.

One class of mistakes, very costly to large handlers, may be considered as poor salesmanship—not knowing the proper time to sell or holding for a price higher than the stock is worth. The largest losses are likely to be incurred by those who do not keep thoroughly informed regarding all facts that tend to affect the market. Careless methods of buying and inspecting stock, the practice of handling cheap, inferior grades and misrepresenting them, or holding them for the price of good stock—such ways have been the undoing of dealers in some markets.

A FEW CHIEF POINTS.

The main, or late crop of potatoes is shipped chiefly from the States along or near the northern border. About half the potato crop is sold; the rest is accounted for by waste, shrinkage, seed, and starch requirements, and home use. A little more than one-fourth of the average main crop is shipped to market in car lots or in their equivalent in bulk lots.

The practical question is when, where, and how to sell the commercial half of the crop. Prices seem closely related to production, which in turn depends on acreage and yield. Reports of heavy plantings in early sections suggest caution, especially if production was light the season before. A season of heavy planting often follows a season of light production and high prices. For this reason, it is unsafe to increase acreage heavily in the year following a high-price season, especially if early reports show that farmers in general are increasing their plantings; but supply and price depend on yield as well as on acreage, and the yield of the main crop can not be forecast until August or September.

An estimated yield above four bushels per capita has been usually followed by a season of low or falling prices, while a yield around three bushels per capita has been often followed by rising prices. For yields between these points the indications are not clear, but the general price tendencies during many such seasons intimate that in cases of doubt the chance of gain may be hardly worth the cost and risk of long storage.

The chief price-making factors are acreage, total supply, losses from rot, disease, or freezing, the demand, and the competition with imported potatoes or with the early crop. There are also fluctuating prices caused by weather and conditions of transportation.

Crop and market news supplied by the United States Department of Agriculture includes crop and market reports and summaries of many kinds published at eight field stations located in the prominent shipping sections and at about a dozen market stations, including the Washington office. These reports contain the necessary facts of production, condition, shipment, prices, demand, and quality.

By persistently using and comparing reports from day to day, and season after season, they become more and more useful in showing the potato holder when, how, and where to sell.

The general condition and course of the market is best indicated by the leading grades of the most important commercial varieties in the largest and most active markets.

The reader soon learns to look for certain price changes under given conditions and to detect the early signs of coming price movements.

Among the regular price developments to be looked for in average seasons is a comparatively low price at digging time with some gain as shipments decrease or when winter conditions begin, then several months of moderate ups and downs, and then another swing, upward or downward, with the opening of spring activity.

The proportion of stocks held by dealers on January 1 has often proved an indication of the course of the late winter and spring markets.

The whole matter of good marketing may be summed up under: (1) Careful planning from planting time to day of sale; (2) full use of the crop and market news; (3) good handling, grading, and loading; and (4) readiness to learn from the methods of other commercial potato sections.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1318

GREENHOUSE CONSTRUCTION AND HEATING

GLASS FARMING, or the growing of flowers and vegetables in greenhouses, has become an important industry in the United States, and according to the 1919 census the value of the crop for that year was more than $77,000,000, produced in structures covering nearly 3,800 acres.

High-quality greenhouse products are finding an increasing demand, and the industry offers special inducements to those having a knowledge of and a liking for the work.

Vegetables produced in forcing houses near the markets reach the consumer in a fresh condition, without the delays incident to long shipment.

Products of exceptionally high quality can be grown under glass, as conditions are more nearly under control than in the open.

In selecting a location for a greenhouse industry particular attention must be paid to the labor and fuel supply; also to the accessibility to markets.

This bulletin discusses the construction and heating of greenhouses, giving such information as will be useful to those who contemplate engaging in the business.

Washington, D. C. Issued May, 1923

GREENHOUSE CONSTRUCTION AND HEATING.

By JAMES H. BEATTIE, *Horticulturist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

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IMPORTANCE OF THE GREENHOUSE INDUSTRY.

THE PRODUCTION of greenhouse crops in the United States is an important industry and is constantly increasing because of the demand for vegetable and floral products that can be produced in the modern greenhouse. Furthermore, under favorable conditions the cost of growing greenhouse crops permits the products being sold on the northern markets in competition with those shipped long distances from warmer portions of the country. The fact that greenhouse products are acknowledged to be superior in quality to those grown out of doors contributes materially to the development of the industry. According to the 1919 census there were in the United States more than 17,000 establishments employing some type of forcing structure for the production of plants, flowers, or vegetables. The value of the crop grown in 1919 was about $77,000,000, the glass area covering nearly 3,800 acres.

Success in growing vegetables or flowers under glass, in addition to the skill of the grower, will depend upon the suitability and adequacy of his equipment and the use which is made of it. The fact that the quantity of coal used to maintain each acre of space inclosed in greenhouses at the required temperatures varies from 250 to 500 tons a season indicates the need for the practice of every possible economy. Any feature of the construction of the greenhouse plant, its operation, or its upkeep which affects the quantity of fuel consumed immediately reflects itself as an item of cost in the production of greenhouse crops. Fuel losses in greenhouse heating are sustained because of poorly constructed houses, a faulty heating system, or the lack of repair of the house or the heating unit. As the principles of construction and heating come to be better understood it is altogether likely that greenhouse crops will be more economically produced, thus putting the operator on even a more favorable basis than at present as compared with producers of outdoor crops that are shipped long distances and take a high freight rate.

The production of such vegetables as lettuce, cauliflower, beets, and radishes can be carried on in simple, inexpensive houses. The starting of the plants of cabbage, tomato, eggplant, pepper, and celery can be carried on with even simpler equipment. It is likewise possible to grow many floral or decorative crops in greenhouses requiring only a moderate outlay for their construction and equipment. In many cases the same houses may be used for both flowers and vegetables, but this practice is not usually followed except in small establishments.

Forcing houses are usually a profitable investment when operated in connection with a market-gardening or truck-crop enterprise. Many persons have found a greenhouse to be an excellent means for the utilization of a portion of their time. There are few enterprises so well suited to the needs of middle-aged or older persons who want some form of work as an entire or partial source of livelihood. Not all locations are adapted to greenhouse work, and the advisability of the undertaking for the individual must be determined after a careful study of the conditions. Most of the large greenhouse enterprises had their beginning in a small way, and it is always well for the beginner to locate his enterprise so that he will have room for expansion. Where there is but little chance that the enterprise will develop into a large business there may be an excellent opportunity for profitable plant growing to supply persons in the immediate vicinity.

LOCATIONS SUITED TO GREENHOUSES.

In locating commercial greenhouse ranges several factors should be considered, the most important of which are (1) fuel supply, (2) labor, (3) marketing facilities, (4) soil, and (5) water. It requires from 250 to 500 tons of coal to maintain an acre of glass at the proper temperature for the season. The lower figure refers to ranges growing cool crops, such as lettuce, where the temperature is maintained at 40° to 55° F.; the higher figure, to ranges growing crops demanding temperatures up to 75° F. Greenhouse plants so located that they can obtain cheap fuel have a distinct advantage over those less fortunately situated. A large plant should be so located either on a railroad or a canal that fuel can be placed in the boiler room without expensive handling. Contrary to the general belief, there is no marked variation in the quantity of fuel required for greenhouse establishments located in the different sections of the country. Many have been located at a distance from large markets because the fuel required could be secured more cheaply. Marked economies may result from such a location, as the weight of the fuel required to produce a greenhouse crop is many times the weight of the crop itself, and it may be cheaper to ship the crop than to ship the fuel.

An abundance of specially trained labor is essential to success in the greenhouse industry. Highly intensive working of the soil, such as is necessary to success in this business, requires that every square foot in the houses be utilized to the fullest extent, and this requires considerable labor. The average annual value of the greenhouse crop of the United States is about $20,000 per acre, and it is evident that each acre of glass will readily furnish profitable employment for two or three men. While it may be easier to obtain labor in sections where the industry is already developed, this need not be a deciding factor in the location of a greenhouse, as help can soon be trained to perform the work in a satisfactory manner.

Nearness to market is desirable in many ways, but this need not be a deciding factor. It may be a better plan to build the greenhouse range where cheap land, fuel at low cost, and plenty of labor can be had, provided good shipping facilities are available. It is essential that the crop be placed on the market in the shortest practicable time, and the location of the plant where the product can be moved by truck, by fast express, or by other means that will put it on the market a few hours after it is harvested undoubtedly has a distinct advantage. Although it is desirable that the greenhouse enterprise be located on good soil, this is not an essential, as good soil can soon be developed. When it is possible to make a selection of the type of soil on which the plant is to be located, a loam is to be preferred for most purposes. In houses without benches the natural soil is usually employed, while in houses fitted with benches and in other houses where the soil is changed from time to time it is possible to modify it to suit the crops to be grown.

Greenhouse crops require large quantities of water, and an ample never-failing supply should be assured. For small enterprises it is usually more economical to use water from the city mains if it can be obtained. Larger plants requiring great quantities of water may find it more economical to maintain their own pumping plant and storage facilities.

The small greenhouse enterprise is often started as an adjunct to some other business, such as a store, and for this reason it is desirable to locate the structure so that the work can be performed easily. Many locations are totally unsuited to even small greenhouses. With the exception of a few crops grown in the dark, sunshine is essential to the growth of greenhouse crops. If the only available location is such that the greenhouse will be shaded for a considerable portion of the time, or if the location is such that excessive amounts of smoke, dust, acid fumes, etc., are present in the air, it may be inadvisable to enter the business. When it is possible to choose a location, a well-drained piece of land should be selected, preferably with a southern slope and where the house will be protected from winds by forests, hills, or artificial windbreaks. In many cases these small greenhouses are cared for by some member of the family, and it is often desirable to heat such a structure with the hot water or steam heater serving the residence. When this plan is to be followed, the greenhouse should be located at a higher level than the heater, to assure circulation.

LAYOUT OF THE PLANT.

The economical operation of a greenhouse plant depends largely upon the plan and arrangement of the units, such as the boiler room, the packing house, and the forcing houses. It is desirable that the packing room should be accessible to all of the houses without going outdoors or using indirect routes. The arrangement of the houses and of the remainder of the plant will be determined by the type of house to be erected and by the character of the site. Figure 1 illustrates an arrangement often employed for detached houses. It will be noted that this arrangement offers an excellent opportunity for the economical handling of the product. Figure 2 shows a range of ridge-and-furrow houses with the boiler room and workroom so arranged that it is possible to receive coal and manure and handle, pack, and ship the product with the minimum of labor.

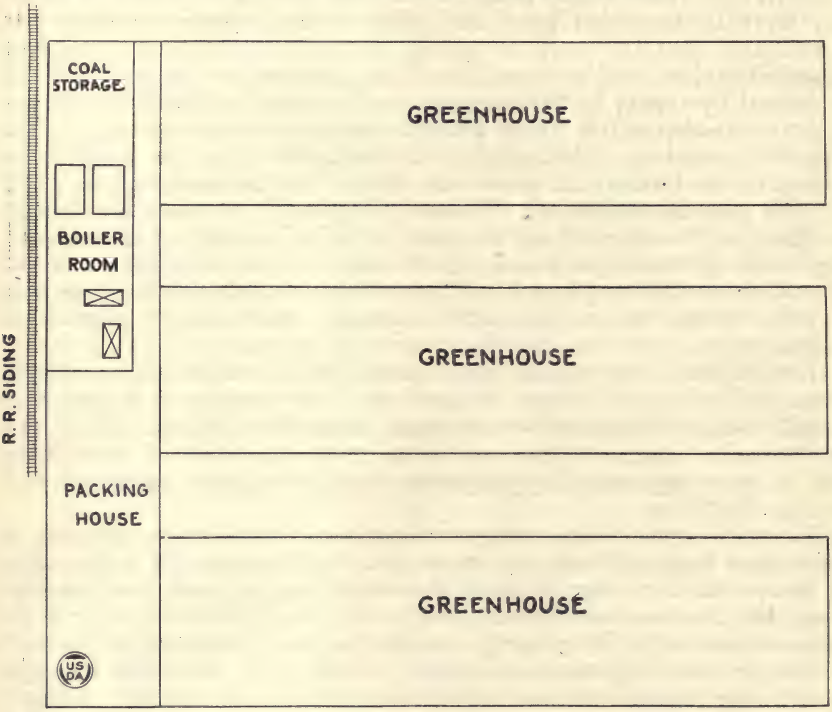


FIG. 1.—Detached greenhouses with head house across one end, a plan often employed in building ranges of such houses. This arrangement facilitates the economical handling of the work.

Figure 3 shows a greenhouse built without thought as to economical operation. The boiler room is far removed from the packing house and is at a higher level than most of the greenhouses. The plant is upside down so far as the heating plant is concerned, as it is necessary to pump all the condensation back to the boilers. No railroad siding is provided, and it is necessary to haul all the fuel to the boiler room and haul all the product to the railway station. Such a plant costs far more to operate than does a well-planned one.

When it is desired to build a commercial range of greenhouses the plan for the whole range should be made at the start, so that the first house will be a unit that will fit in with the later houses, in order to create a harmoniously operating plant. It should be remembered that most greenhouse ranges have small beginnings and that the location of the first house should have careful consideration.

TYPES OF GREENHOUSES.

Several well-defined types of greenhouses are in use. The simplest is the lean-to house, this having a shed roof, built against some existing structure.

The detached house, as its name signifies, is an independent structure and may be of any size up to one covering from 1 to 2 acres of ground. For convenience in operating the plant, such houses are usually built in rows and connected by a head house built across the ends of the houses, as shown in Figure 1.

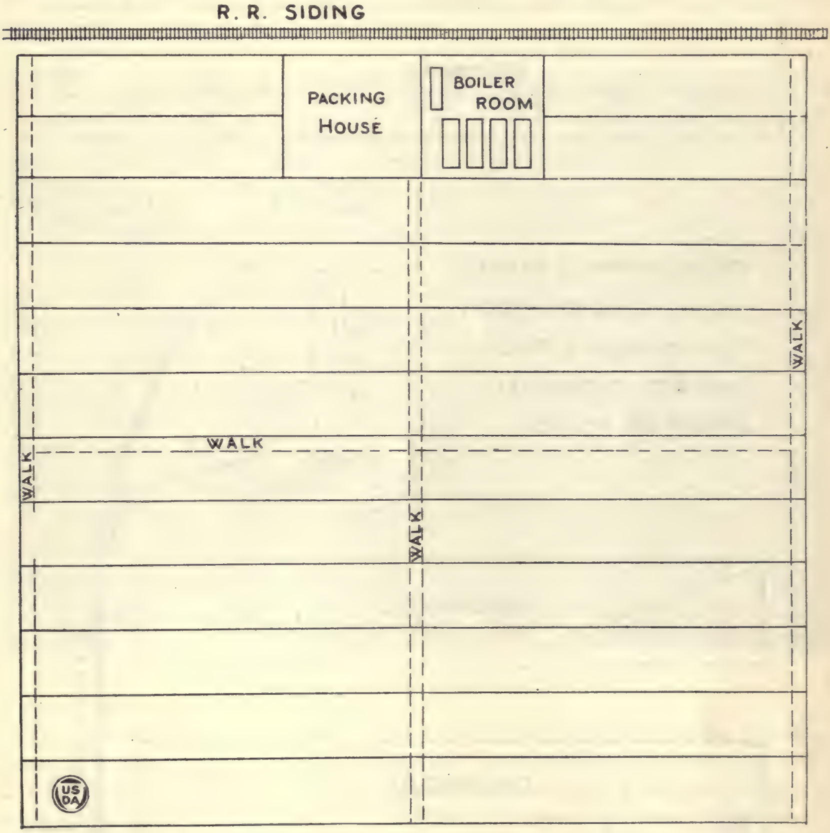


FIG. 2.—A range of ridge-and-furrow houses; an excellent arrangement for reducing labor to a minimum.

Another type, known as the "contiguous" house, consists of several independent units built side by side and using the same inside walls.

Another extensively used type is known as the "ridge-and-furrow house," the arrangement of the units in this type being similar to those in the contiguous house, but the inside walls are omitted, the gutters being carried on posts, giving in reality one large house. (Figs. 4 and 5.)

The lean-to house is simple, inexpensive, and fairly satisfactory for some purposes and some locations. The contiguous type has little to recommend it, except where not more than two are built side by side, thus permitting of side ventilation on one side of each house, a thing that is impossible except in the two outside houses when several are built side by side. Both the ridge-and-furrow and the detached types of houses have much to recommend them, and most of the houses of new construction are of these types. As pointed out in an earlier paragraph, the lean-to house always has a roof sloping one way.

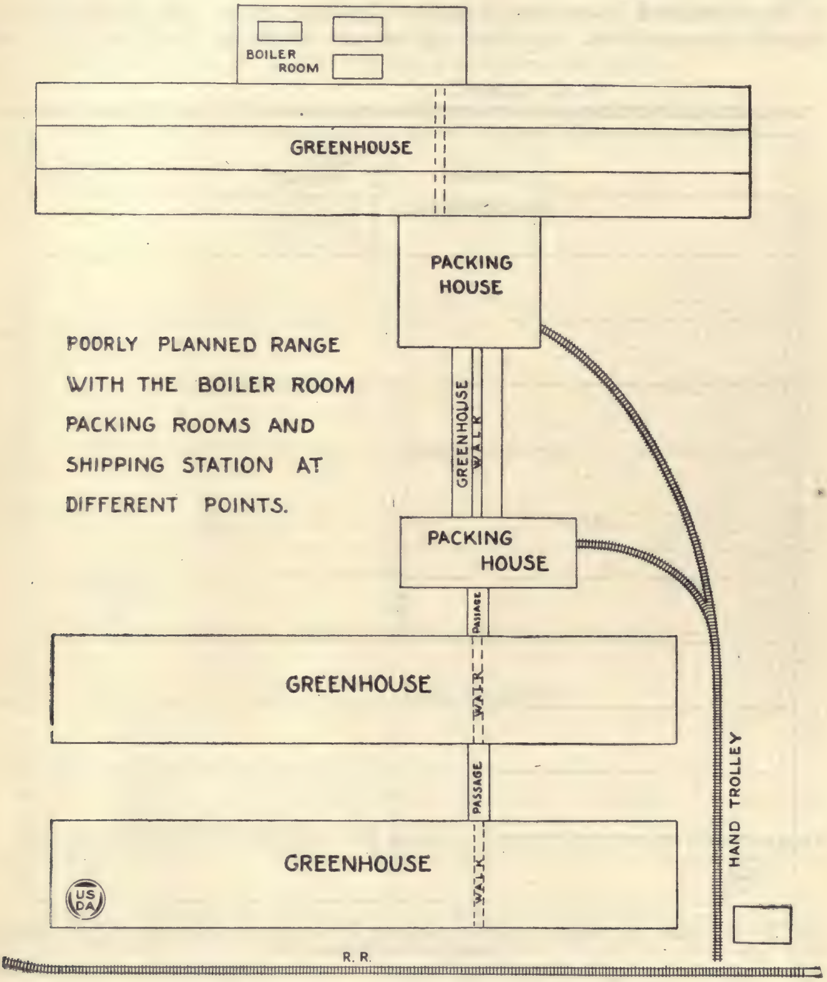


Fig. 3.—A poorly arranged greenhouse plant.

The other types may have roofs with the ridge in the middle of the structure, this being termed an "even-span house," or with the ridge three-fourths or any other fractional distance from one wall or the other, making an uneven-span roof. Greenhouses with uneven-span roofs are particularly desirable for sidehill locations. Any of these four types of greenhouses may have curved eaves or other special features, but the small house for the beginner should be as simple and as inexpensive as is consistent with the purpose for which it is to be used. When, for instance, it is the purpose to produce vegetable plants, and in some cases some of the more common ornamental bedding plants, such as geraniums and scarlet sage, the houses may be of the simplest construction. If, however, it is the purpose to grow winter vegetables and flowers for sale, the houses must be more elaborate and, of course, more expensive.

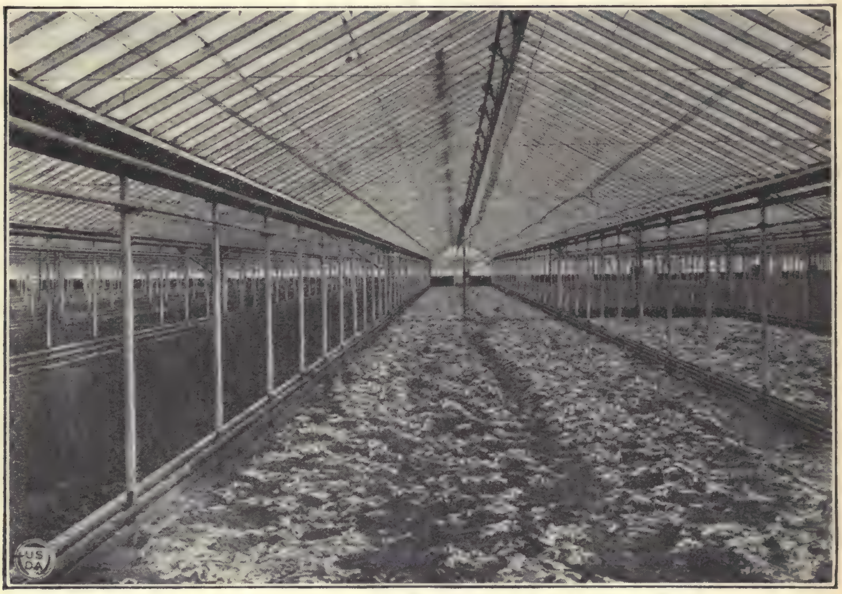


FIG. 4.—Interior of ridge-and-furrow greenhouses.

The necessity for a careful study of the conditions, so as to determine the particular line of work that is most likely to succeed, can not be overestimated. Neither can the advisability of starting with simple equipment and the production of easily grown crops be too strongly urged. Many beginners in the greenhouse business fail because they attempt the production of such difficult crops as violets, roses, orchids, or muskmelons, when they probably would have succeeded with bedding plants, vegetable plants, or even greenhouse lettuce or carnations.

SIZES AND PROPORTIONS OF GREENHOUSES.

It is usually better for those without greenhouse experience to start with a small unit, to which additions can be made. At the same time the house should be so large that it will justify the full time and attention of the operator. A surprisingly large number of plants can be produced in a well-planned greenhouse of small size. In planning the house, it should be remembered that the proportions of the structure markedly affect the ease with which the work can be handled and the economical use of the space inclosed.

Most of the small houses used by beginners in the business are devoted to crops that make greenhouse benches desirable, and the house should be of such width that the space can be economically divided between walks and benches. They should be so proportioned that there is just room in the walks for the operator, and in the case of a house over 50 feet long for a small truck or wheelbarrow for the placing and removal of the soil, manure, and the plants themselves. When the house is of such length that the use of the truck or wheelbarrow is unnecessary a walk 2 feet wide will be ample. The benches should be of such width that an adult can just reach across them. A lean-to house 6 feet 8 inches wide outside dimensions and with one walk 2 feet wide allows just room enough for one bed 4 feet wide, this being about as wide as the average person can reach across. (See Fig. 16.) The house shown in this figure is a type very frequently built by beginners.

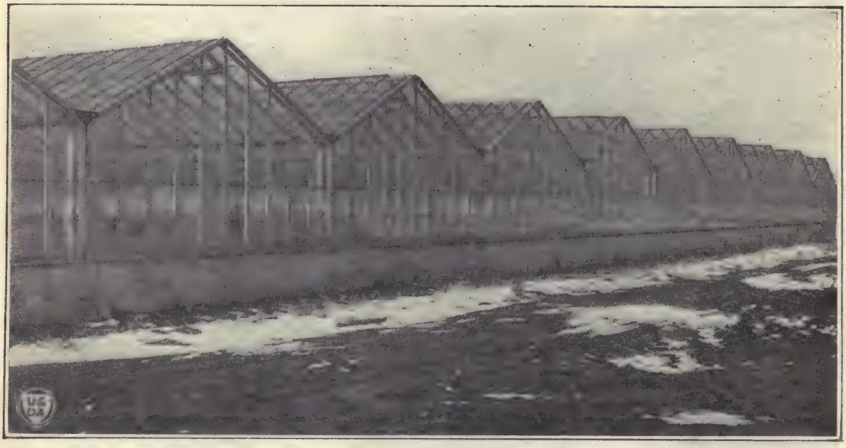


FIG. 5.—Exterior of a range of ridge-and-furrow greenhouses.

Lean-to houses can be built of any desired width and with two or more walks, but this type of house is not at all common. (Fig. 6.) A house 10 feet wide allows room for a 2-foot walk in the middle and two 3½-foot benches.

The same considerations hold for detached houses as are brought out in Figure 17, this showing an even-span house 10 feet wide. Where benches are to be used the next economical width of a house is 20 feet, allowing for two walks, two side benches, and one middle bench about 7 feet wide, the middle of which could be reached from either aisle. (See Fig. 18.) The above considerations as to width do not apply to houses not fitted with benches where the crops are to be grown on the ground or in slightly raised ground beds, as is usually the case with vegetable houses. These structures can be any desired width, as in such houses it is usually possible to cultivate the crops with hoes or other long-handled tools, or from boards resting on the curbs or on low trestles set on the walks along the sides of the beds. At the present time the tendency is toward very large houses, those 60 to 80 feet wide and 500 to 600 feet long being not uncommon. The house may be of any required size, depending upon the use to be made of it and the character of the site.

GREENHOUSE MATERIALS AND PARTS.

It is always desirable to secure greenhouse materials from concerns making a specialty of their manufacture, as practically all parts of a greenhouse are of special character and have been evolved through many years of experience in building such structures. The earlier houses were of extremely heavy construction, and while strong they were open to the objection that a large portion of the light was kept out by the size of the framework. The structure has been gradually lightened through the use of better materials, until the frame of the modern house presents very little obstruction to the entrance of light.

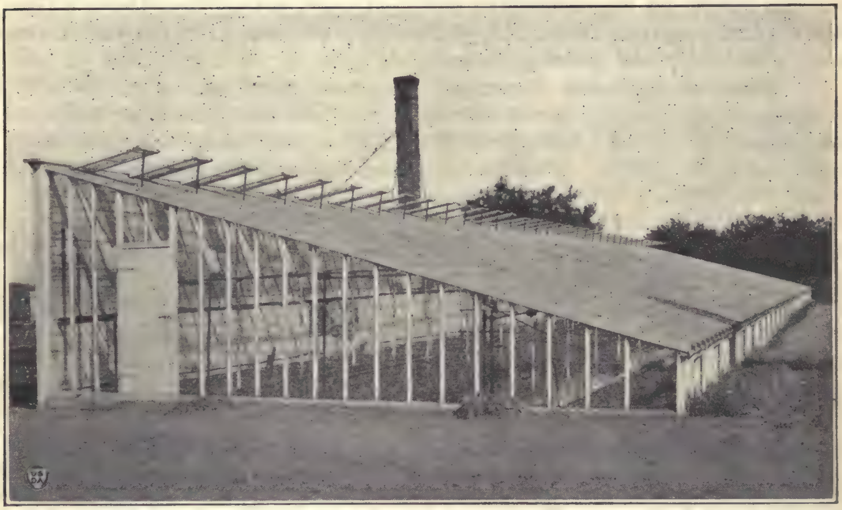


FIG. 6.—Lean-to house with two or more walks, which may be of any desired width. Instead of building the house shown here against some existing wall, it was constructed with one wooden wall.

FOUNDATIONS.

The foundation of the greenhouse must not only carry the weight of the structure but must tie it to the ground and support it against the force of the wind and the weight of snow and ice. Many of the difficulties experienced by greenhouse owners have been due to the fact that their houses were built without sufficient foundations. The character of the foundation necessary is determined by the kind of house to be built and by the subsoil. With simple houses supported on wooden posts it may be sufficient to have concrete or masonry footings under these posts, while with semi-iron or steel-frame houses it may be necessary to have continuous footings under the walls, these to extend below the frost line and to be of sufficient size to support the structure during the heaviest snowstorms and the highest winds. Without sufficient foundation for the house, settling is almost sure to occur, causing the glass to loosen or be broken, the doors to sag, the gutters to get out of line, and a general weakening of the structure.

THE SUPERSTRUCTURE.

The frame of the greenhouse may be of wood or a combination of wood and steel. The all-wood structure, as the name suggests, has wooden posts, sheathing, gutters, sash bars, etc. The portion of the wall from the top of the foundation to where the ventilators begin is usually sheathed, covered with paper, and then sided. The house is fitted with wooden plates and gutters, the latter resting on top of the side posts and with the braces, ties, and purlins frequently used on the inside of the structure made of steel pipe when the width of the house requires such support. Many ridge-and-furrow houses are of this type of construction.

The semi-iron house is a combination of wood and steel members, having as a rule pipe posts embedded in the concrete side walls and an angle-iron eave plate or an iron gutter attached to the posts and sash bars by special fittings. These houses have inside pipe posts with pipe or angle-iron purlins and purlin braces. Such a house is described later. (See Fig. 18.) In this house the pipe posts are embedded in the concrete side walls, the method used being to set the posts in position first and pour the concrete around them. This house is 20 feet wide and has two rows of inside posts, but for narrower houses one row of posts is sufficient. For houses of moderate width this type of construction is admirable.

The steel-frame house differs from the semi-iron house in that the roof is supported by built-up structural members carried by side posts set in the side walls. For houses of this type up to 40 feet wide no inside posts are ordinarily used, while houses as wide as 80 feet can be built with but two rows of inside posts, these being made of steel pipe, steel columns, or of wood. The steel-frame house is generally used for large-sized units. However, the person just starting in the greenhouse business with the idea of growing the simpler crops will usually find a less expensive type satisfactory for his purposes.

Whether the all-wood, the semi-iron, or the steel-frame type of house be selected, the superstructure while sufficiently strong to withstand the hardest storm must be made of parts so small that little shade will be cast. This requirement has led to the general use of iron and steel instead of wood. For certain parts of the greenhouse wood is looked upon as an ideal material, while for other parts iron or steel is best. The uses to which each material is best adapted will be discussed in the following pages.

POSTS.

The posts supporting the greenhouse side walls and roof may be of wood, wrought-iron or steel pipe, or of structural steel in the form of bars, channels, or I beams. The conditions in a greenhouse are particularly favorable for decay or corrosion, and whatever material is used must be well protected from decay or rusting. Wood should be of a decay-resisting timber, such as redwood, cedar, or locust, and it is usually advisable to soak the portion that goes in the ground in creosote or some other wood preservative, and embed it in concrete. Figure 7, *C*, shows the usual method of constructing greenhouse walls with wooden posts. When iron-pipe posts are used for the outside walls they are as a rule set in concrete. (See Fig. 7.) Wooden posts are employed only when wooden gutters are used and the gutter is secured to the top of the posts. When steel posts or pipe posts are used, either with wood or semi-iron houses, the gutter or angle-iron eave is secured to the posts by means of special post top fittings. (See Fig. 8, *A*.) When the steel-frame house is employed, the roof trusses are riveted to the posts, using special post top fittings.

Inside posts may be of wrought-iron, steel pipe or structural steel, or of wood. The tendency is toward the use of steel pipe or structural steel, as this class of material is light, strong, and of small size as compared to wooden members suitable for the same uses. (Fig. 8, *B*.) In wider houses the same material is used, as is brought out in Figure 8, *C*. In all cases where pipe is used for inside posts and braces it is necessary to use special fittings to fasten the members together, as shown in Figure 8.

BRACES, TIES, AND PURLINS.

The sash bars carrying the glass must be supported at close intervals by the frame of the greenhouse. The distance between these supports varies with the type of house and the size of the sash bar, but unless these supports are spaced not over 8 feet apart trouble is likely to be experienced through sagging and possible breakage, especially under heavy loads of ice and snow. The purlins employed to give this support in wooden or semi-iron houses are of angle iron, I-beam steel, or pipe. They are either carried on top of posts or by braces to the posts. (See Fig. 8, *B* and *C*.) In steel-frame houses the purlins are carried either on posts or by the trusses supporting the roof.

The greenhouse must bear heavy strains due to winds, snow, and ice and must be well braced so that it will be perfectly rigid. The side walls of wood and semi-iron houses are usually tied together at the eaves with rods fitted with turnbuckles. There is a tendency for the houses to spread, owing to the weight of the roof, and these ties counteract this. The tie rods are usually spaced about 10 feet apart. The roof is also braced against twisting by tie rods running in diagonal directions from the purlin braces to the eaves. These braces are usually installed only every third or fourth set of purlin braces. Even in steel-frame houses this bracing is desirable.

GUTTERS AND EAVE PLATES.

The wooden gutter is expensive and unless kept well painted is short-lived and liable to leak through the joints. Cast-iron and steel gutters are used and give satisfactory results, but must be kept well painted, or they, too, will deteriorate. In houses such as ridge-and-furrow houses and contiguous houses inside gutters must be used, and these should be of as simple construction as possible. Figure 7, *B*, shows a type of gutter that is simple and efficient.

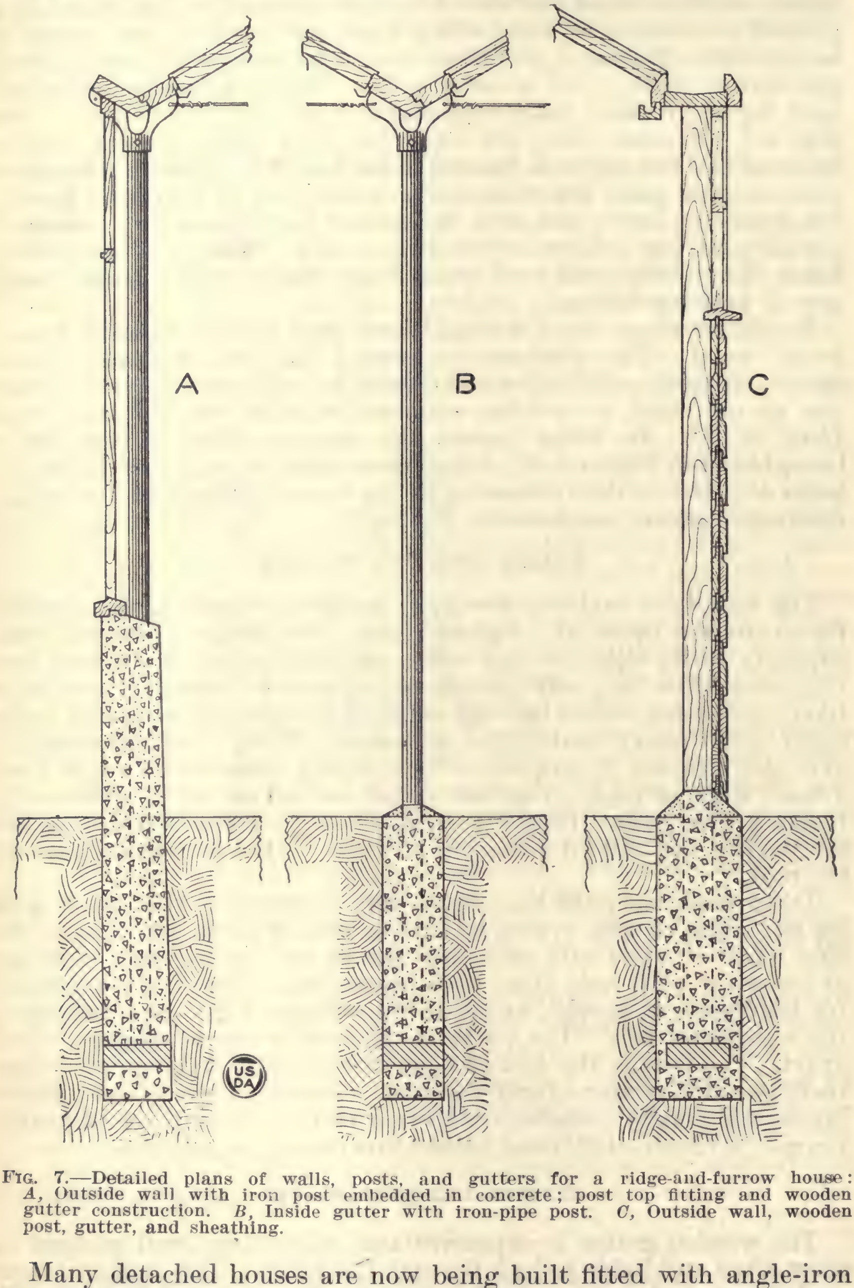


FIG. 7.—Detailed plans of walls, posts, and gutters for a ridge-and-furrow house: *A*, Outside wall with iron post embedded in concrete; post top fitting and wooden gutter construction. *B*, Inside gutter with iron-pipe post. *C*, Outside wall, wooden post, gutter, and sheathing.

Many detached houses are now being built fitted with angle-iron eave plates, such as are illustrated in Figure 8, *A*. The house shown on the title-page of this bulletin is built in this manner. Such construction is long lived, strong, and does not allow snow and ice to lodge on the eaves of the house, but, of course, does not collect the water running off the roof and convey it to the sewer. Provision for such drainage can be made by constructing a gutter alongside the greenhouse, into which the water can fall from the roof.

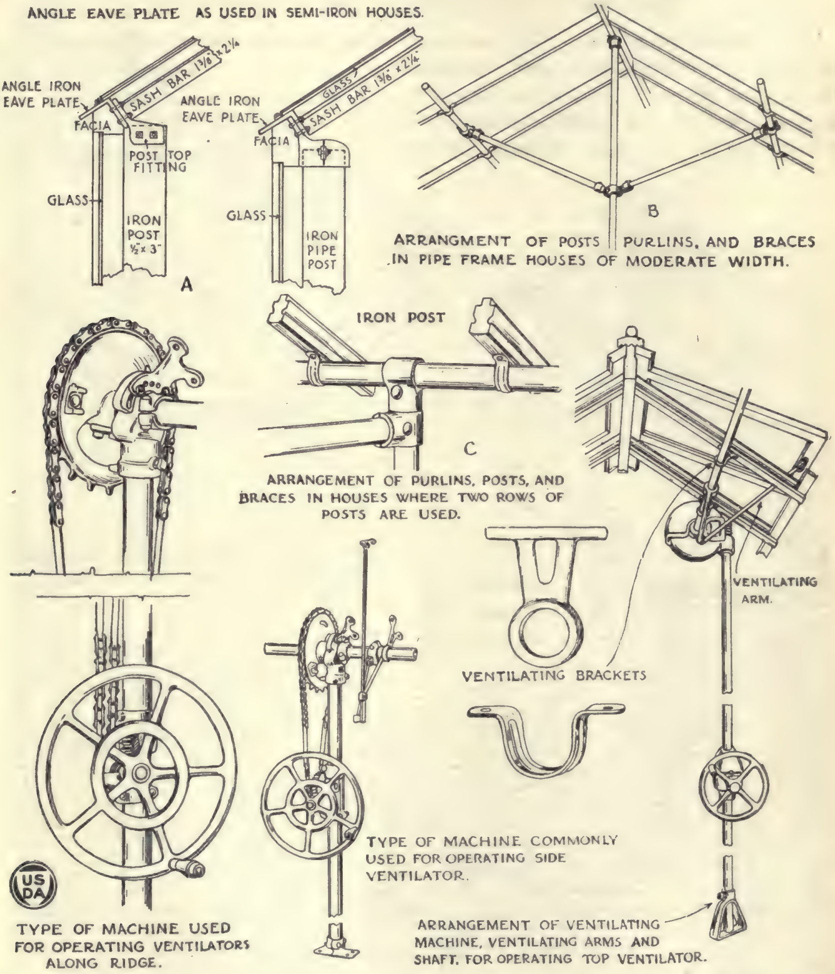

ANGLE EAVE PLATE AS USED IN SEMI-IRON HOUSES.
ANGLE IRON EAVE PLATE
SASH BAR 1 3/16" x 2 1/4
FACIA
POST TOP FITTING
GLASS
IRON POST 1/2" x 3"
A
ANGLE IRON EAVE PLATE
GLASS
SASH BAR 1 3/16" x 2 1/4"
FACIA
GLASS
IRON PIPE POST
B
ARRANGMENT OF POSTS PURLINS, AND BRACES IN PIPE FRAME HOUSES OF MODERATE WIDTH.
IRON POST
C
ARRANGEMENT OF PURLINS, POSTS, AND BRACES IN HOUSES WHERE TWO ROWS OF POSTS ARE USED.
VENTILATING ARM.
VENTILATING BRACKETS
TYPE OF MACHINE COMMONLY USED FOR OPERATING SIDE VENTILATOR.
TYPE OF MACHINE USED FOR OPERATING VENTILATORS ALONG RIDGE.
ARRANGEMENT OF VENTILATING MACHINE, VENTILATING ARMS AND SHAFT, FOR OPERATING TOP VENTILATOR.

Fig. 8.—Details of construction of special features for a wooden or semi-iron greenhouse: *A,* Iron and iron-pipe posts with special top fittings. *B,* Arrangement of inside posts and braces where one row of inside posts is used. *C,* When two rows of posts are used they are usually placed under the purlins and tied together as shown.

RIDGE CONSTRUCTION.

In wooden and semi-iron greenhouses the ridge members are usually of wood. (Fig. 9.) The size and type of the ridge parts are determined by the character and size of the house, but typical ridge parts are shown in the illustration. It will be noted that the sash bars are inserted so far below the top of the ridgepole that there is room between the top of the sash bars and the cap for the ventilator sash. In some steel-frame houses the wooden ridge parts are carried on top of a steel I beam, this construction being made necessary on account of the methods used in constructing the roof frame. The wooden parts are used for convenience in attaching sash bars, cap, and ventilators.

SIDE WALLS AND ENDS OF THE GREENHOUSE.

The portion of the side walls of the greenhouse not occupied by masonry foundations and ventilating sash is constructed of sash bars and glass. In cases where high masonry walls are used, the remainder of the side walls is usually taken up with ventilators. (Fig. 10.) In cases where the ventilators occupy but part of the space between the top of the masonry walls and the eaves, it is necessary to use a plate located at the bottom of the ventilators, this serving as an attachment for the sash bars.

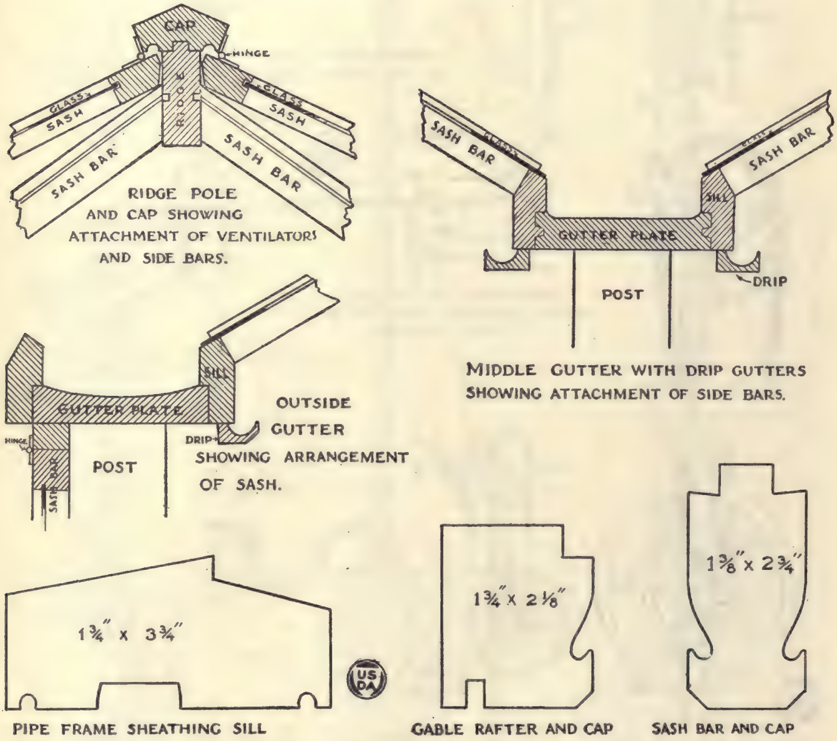

CAP
HINGE
RIDGE
GLASS
SASH
GLASS
SASH
SASH BAR
SASH BAR
RIDGE POLE AND CAP SHOWING ATTACHMENT OF VENTILATORS AND SIDE BARS.
SASH BAR
GLASS
SASH BAR
SILL
GUTTER PLATE
POST
DRIP
MIDDLE GUTTER WITH DRIP GUTTERS SHOWING ATTACHMENT OF SIDE BARS.
SILL
GUTTER PLATE
HINGE
DRIP
POST
SASH BAR
OUTSIDE GUTTER SHOWING ARRANGEMENT OF SASH.
1¾" x 3¾"
1¾" x 2⅛"
1⅜" x 2¾"
US DA
PIPE FRAME SHEATHING SILL
GABLE RAFTER AND CAP
SASH BAR AND CAP

FIG. 9.—Some greenhouse parts made of wood.

Aside from the portion occupied by masonry construction and doors, the ends and gables of the greenhouse are usually of sash-bar and glass construction. Owing to the pressure exerted by the wind on such exposed parts, it is necessary that the gable end be well braced. In small houses the area exposed is so small that the purlin ends are a sufficient brace. In semi-iron houses a set of posts and purlin braces is sometimes placed at each end to give strength to the structure. In steel houses one of the roof trusses is placed at each end and the gables attached to these. The doors are nearly always placed in the ends of the greenhouse. In large structures these doors should be of such size that easy access can be had to the structure for the placing and removal of soil, manure, and implements required in the work. (Fig. 11.)

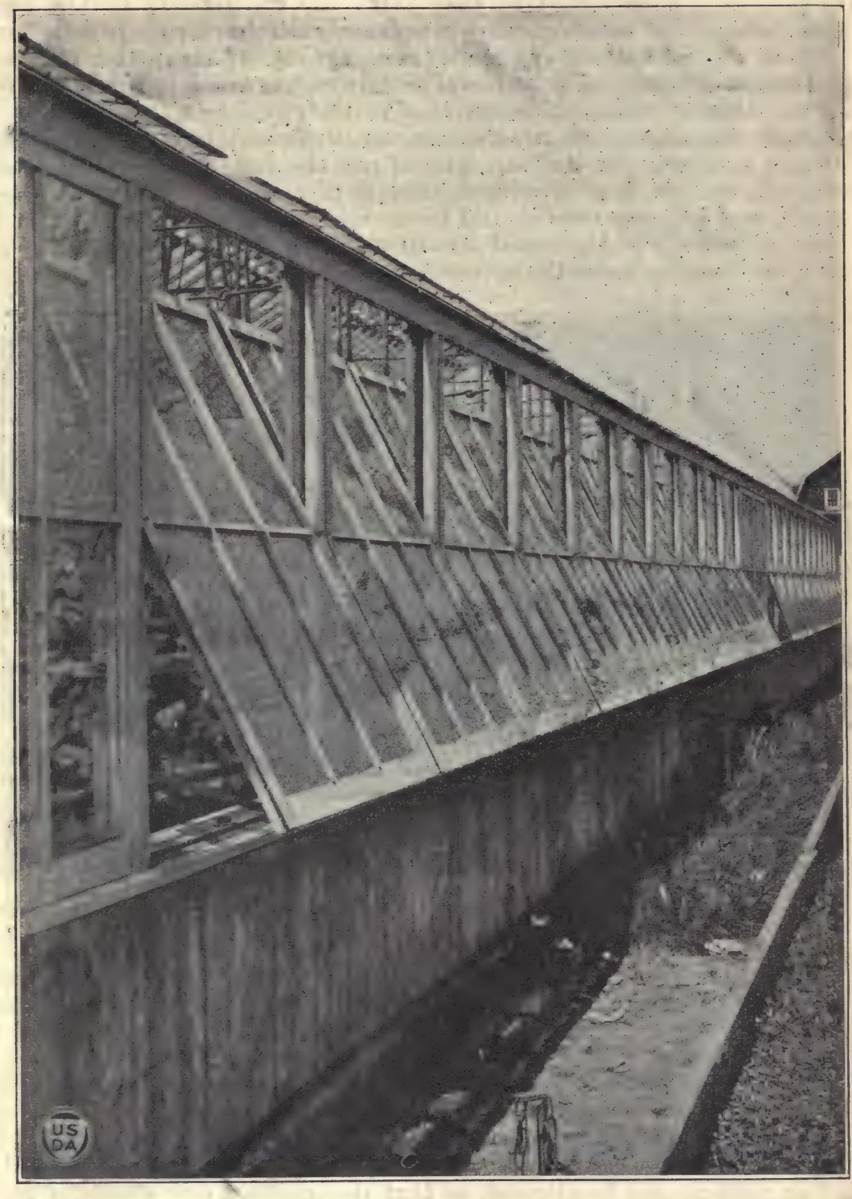


FIG. 10.—A type of construction where the portion of the wall of the greenhouse between the masonry and the gutter is taken up with ventilators.

SASH BARS.

The sash bars in a greenhouse serve the same function as the rafters in a house—that is, they carry the roof itself, in this case the glass. The usual form of wooden sash bar is illustrated in Figure 9. Sash bars are made in a variety of sizes and shapes. There are several makes of metal sash bars, but wood is most largely used. Heart cypress is the material ordinarily selected for the making of sash bars, and needless to say it should be of first grade. Where it is possible the bars should run the full length of the roof without splices, but in wide houses it is necessary that splices be made, and extreme care should be exercised to make these tight and strong. Owing to the small size of the sash bar, metal plates, as a rule, are used to make the splice strong.

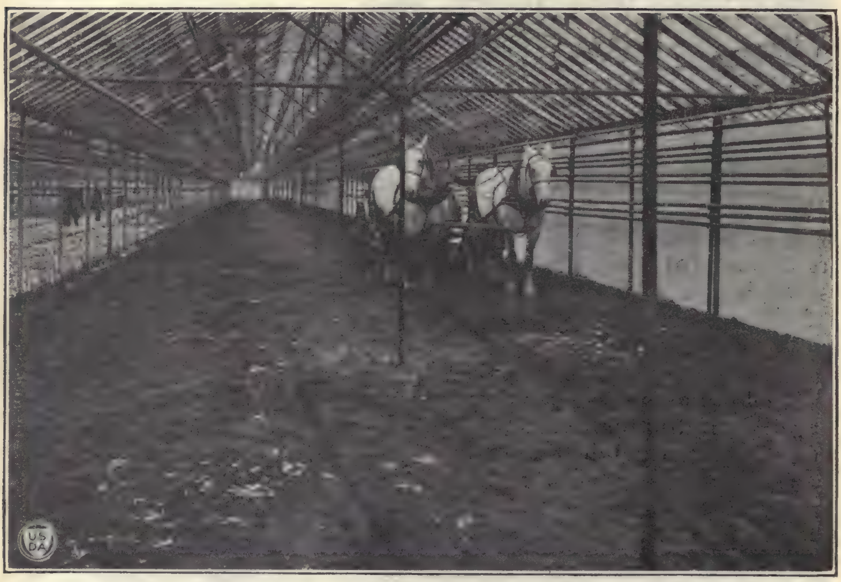


FIG. 11.—Hauling manure into a greenhouse fitted with doors in the ends large enough to admit a team and dump wagon.

Sash bars are spaced to accomodate the width of the glass to be used. Most greenhouse glass is 16 inches wide by 24 inches long. The sash bars have a tongue one-half or five-eighths of an inch wide, and this comes between the different courses of glass, so the sash bars must be spaced 16½ or 16⅝ inches apart, as the case may be. As a rule, no extra clearance for the glass need be left, but where the sash-bar tongues are full dimension and are heavily coated with paint an additional clearance or space of one thirty-second to one-sixteenth of an inch should be allowed, so that the glass will fit close but not bind along its edges. In houses using angle-iron eave-plate construction the sash bars are attached by special fittings, these being bolted or riveted to the plates. The sash bars are attached to pipe purlins by clips, such as are shown in Figure 8, *C*, to angle purlins by bolts or screws, and to the ridgepole by screws or nails.

MISCELLANEOUS STRUCTURAL PARTS.

Practically every part of the greenhouse is of special construction, having been developed through a long period of time and especially adapted to some particular part of the structure. In the foregoing paragraphs some of these special fittings and parts have been described. Figures 8 and 9 show these and other parts. It is never advisable to attempt to use any but the parts and fittings adapted to the purpose. These can be procured from firms making a specialty of their manufacture.

VENTILATION.

Any greenhouse, however small, must be fitted with suitable means for ventilating the structure. In the lean-to house, such as is shown later (see Fig. 16), the ventilators as a rule are placed in the side walls below the gutter and in the roof along the ridge. In detached houses, side ventilation and roof ventilation are usually deemed necessary. The ventilators in any house may be placed at intervals of every few feet or may be a continuous line of sash extending the length of the house. For most types of houses the latter kind is preferable. For roof ventilation the sash is hinged at the ridge, the joint being protected by a cap extending over each side of the ridgepole. (Fig. 9.) The ventilators are operated by a machine so arranged that it is within convenient reach of the operator. Figure 8 shows the arrangement of the ventilators and ventilating machines in a medium-sized house. Ventilating machines capable of operating long lines of sash can be obtained, but it is never wise to overload the machines by attaching them to longer lines of sash than they are designed to handle, or breakage may result. In small houses it is sometimes feasible to avoid the expense of a ventilating machine by simply raising the individual ventilating sash and securing it at the desired height with a notched stick or flat iron bar attached to the ventilator sash, with holes every 2 or 3 inches which allow the bar to be secured at any desired point. Such devices are not very satisfactory and should be employed only as temporary expedients.

Side ventilators may be hinged at the top where the joint can be protected by a drip cap, or they may be pivoted in the middle. The illustration on the title-page shows a house with hinged ventilators and Figure 10 one equipped with the pivoted type.

The latter type has many points of advantage, chief of which is the greater ventilation given, but the workmanship must be of the best or trouble will be experienced due to sticking. On the other hand, if too loose, excessive loss of heat will occur. Side ventilators as a rule are operated by machines, but they can be opened and closed by hand. Figure 8 shows some of the more important parts of the ventilating equipment. Planning the greenhouse so that standard-sized sash can be used for ventilators makes it possible to secure these along with the other greenhouse material.

PAINTING AND GLAZING.

Moisture conditions existing in the greenhouse make it particularly desirable that all parts be kept well painted. At least one coat of paint should be applied before the structure is erected. For wooden parts a white-lead, zinc, and linseed-oil paint is best, while a red-lead oil paint is satisfactory for the metal parts. After erection, at least two coats of paint should be given, and it is a good practice to apply at least one coat each year thereafter. New sash bars should have at least two coats of paint before the glass is placed. Unless this is done the putty is liable to come loose through having its oil absorbed by the fresh wood.

There is a great difference in the light-transmitting qualities of different grades of glass, and it is especially important that a good grade be used. The best glass is designated "AA," while the next grade is "A" and the third "B." Grade A glass costs much less than the AA grade and is usually satisfactory for greenhouse glazing. The tendency at the present time is to use large glass, as this means fewer sash bars to cast shadows in the houses. Most of the houses now being built are arranged for glass 16 inches wide by 24 inches long. The glass is lapped one-eighth of an inch, this being sufficient to prevent leakage. A greater lap than this would be likely to cause breakage, due to the freezing of moisture between the panes.

Greenhouse glass is bedded in putty or some other glazing compound for the purpose of making the roof water-tight and to exclude cold air. The putty or other glazing material may be applied to the sash bars, the glass pressed down into it and then secured in place with special five-eighths-inch glazing nails, two about 2 inches from the end of the pane, two about the middle, and two directly below the lower edge of the pane, to keep it from slipping downward. In setting the glass it should be remembered that most glass is slightly curved, or is "right" and "left" according to the term used by glaziers. The glass should all be placed with the curve up, so that the joints will be perfectly tight.

GREENHOUSE HEATING.

Fuel is one of the large items of expense in the operation of a greenhouse. Economical heating equipment properly handled is essential to the profitable operation of the plant, and careful attention to the planning and installation of this part of the equipment of the greenhouse is necessary. The finest greenhouse may give unsatisfactory results because of poor heating facilities. There are many forms of heating equipment for greenhouses, and the one best adapted to the needs of a particular case must be determined by such considerations as the size and type of the house, the crops to be grown, the attention that can be given the heating plant, and the kind of fuel available. The requirements of a heating system are (1) it must be capable of maintaining the proper temperature for the crops to be grown, (2) it must be economical in fuel consumption and not require too close attention, (3) it must be adapted to the fuel to be used, and (4) its cost must not be out of proportion to that of the remainder of the plant and to the value of the crops to be produced.

OIL AND GAS HEATERS AND STOVES FOR SMALL GREENHOUSES.

The Department of Agriculture receives frequent inquiries as to the suitability of oil and gas heaters for small greenhouses. Such devices are adapted only to very small houses, and, owing to the injurious effects of the products of combustion, extreme care must be taken to ventilate properly or the plants will be injured, if not killed. Such heaters should have a pipe for the removal of the products of combustion, and their use is not to be recommended except as a temporary expedient.

Coal and wood stoves are also objectionable, owing to the difficulty in obtaining an even distribution of the heat and to the dust that is always incident to their operation. It would be unwise to build a greenhouse with the intention of depending on such heaters.

FLUE HEATERS.

Flue heaters made of brick or masonry located under the benches and running the length of the house are sometimes used, and while they are superior to stoves and similar devices, only fair results can be expected from their use. Where low first cost is essential and where only crops requiring low temperatures are to be grown, their use may be advisable. They are usually constructed with the furnace at one end of the greenhouse, so that it opens into a separate room, usually the structure used as a workroom. This furnace is usually built of brick, with iron grates and iron doors which may be obtained from firms making a specialty of this type of equipment. The size of the furnace depends on the size and length of the house, but a furnace 13 inches wide, 16 inches high, and 3 feet long is large enough to heat a house 10 or 12 feet wide and 60 to 80 feet long. For the first few feet the flue is lined with fire brick with walls 9 inches thick and arched over the top; the remainder is usually ordinary building brick with 4-inch walls. In long flues the last half may be of terra cotta of suitable size, with the joints closed with fire-clay mortar. The chimney itself may be of brick or terra cotta and should be sufficiently high to give good draft. It is usually located at the opposite end of the greenhouse from the furnace, but in some cases the flue is carried around the inside of the house the entire distance, with the chimney located in the workroom or the opposite corner from the furnace. To insure draft the flue should have a slight rise from the furnace to the chimney. These heaters cause more or less dust, and in houses where they are used it is difficult to maintain the proper moisture conditions. As a means of heating greenhouses these flue heaters leave much to be desired.

STEAM AND HOT-WATER HEATING.

The gravity hot-water heating system with cast-iron boiler and large cast-iron pipe came into general use in greenhouse work as the answer to the demand for something better than the flue heater. The use of this principle in heating is not at all new, as according to historical records the Romans employed hot-water heating systems with copper boilers and copper pipe to heat hotbeds used for the production of winter luxuries. Its use in this country dates back about a half century, and improvements have been made from time to time until the modern hot-water heating system, when properly installed, is highly economical and efficient. Such a system is particularly desirable for small houses and ranges where it is impossible to give close attention to the heater, for a well-planned hot-water heating system can be depended on to maintain a uniform temperature with a minimum of attention. In ranges containing less than 20,000 square feet of glass hot-water systems are usually looked upon as best, while for larger plants steam is believed to be more economical. In large plants where firemen are in attendance most of the time it is possible to maintain a uniform temperature with steam. Steam requires less radiation than does hot water and is usually less expensive to install. However, within the past few years the use of forced-circulation hot-water systems has brought about results comparing favorably with the most efficient steam systems. On the other hand, the development of so-called low pressure and vacuum systems has made steam heat more popular than ever. It is altogether probable that both systems will continue to have their advocates and that both will be used to a large extent. It is believed that gravity-circulation hot-water systems will prove to be the most desirable in small greenhouses.

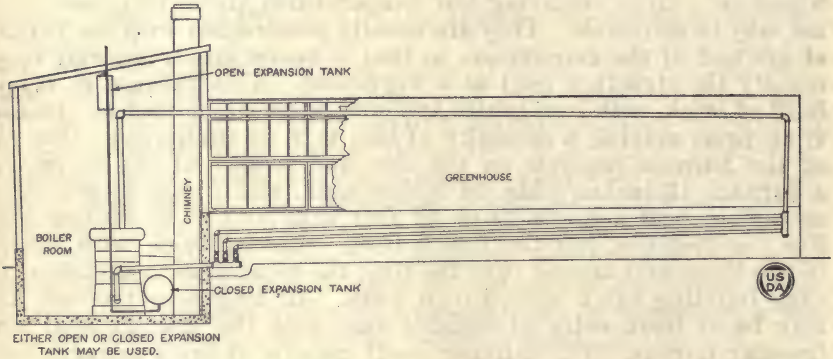


FIG. 12.—Diagram illustrating the principle of hot-water circulation.

THE GRAVITY HOT-WATER SYSTEM.

The gravity system of circulation works on the principle that hot water is lighter than cold water and the water when heated tends to rise to the highest point in the system. The principle is well illustrated by the ordinary house-range boiler, where the water is heated in the coil in the range and passes through the top pipe to the boiler, being replaced at the same time by cooler water through the bottom pipe, this process going on indefinitely. In greenhouse practice the heater is usually located lower than the heating pipes, and as the water heats in the boiler it expands and rises, forcing the cold water ahead of it, and finally makes the circuit of the system and enters the boiler through the return pipes attached near the bottom of the boiler. Figure 12 illustrates the principle upon which this system works. In practice the main or flow pipe is branched so as to provide the proper amount of radiating surface, this illustration being diagrammatic only. In the older installations it was the practice to have the highest point in the system at the end of the house farthest from the boiler, but the modern method is to have it immediately above the boiler, so that the water flows downhill for the entire distance through the house, as brought out in the diagram. The important point to bear in mind in planning a hot-water heating system is to have the pipes uniformly graded and to avoid short turns and bends, so that the water will have an uninterrupted course through the entire system. Another important point to remember is that water expands as it warms, and as the system is filled with water it is essential to provide an expansion tank to take care of this increase in volume.

It has been found that a definite quantity of pipe surface is required to keep a greenhouse at the desired temperature. This is usually figured as square feet of pipe surface and is referred to as "feet of radiation." The most practical method for ascertaining this is by determining the number of square feet of glass in the greenhouse, and after taking into account the temperature to be maintained allow a definite amount of radiation for each 1,000 square feet of glass or its equivalent. By equivalent is meant the side walls of wood or masonry construction, 4 or 5 square feet of each side-wall surface being figured as requiring the same amount of radiation as 1 square foot of glass. Table 1 has been worked out from the experience of greenhouse builders and is as satisfactory perhaps as any that can be devised, but no table can be followed absolutely under all conditions. The geographical location, the exposure of the house to winds, the tightness of the houses themselves, and other factors must be taken into consideration in figuring radiation. The amount of radiation required must be determined by the temperature to be maintained, making proper allowances for any unusual conditions that exist. The figures given in the table are for outside temperatures of zero Fahrenheit, and where the outside temperatures are liable to go lower the radiation should be increased 1 per cent for each degree below zero; that is, for outside temperatures of 10 degrees below zero the radiation should be increased 10 per cent; 20 degrees below zero, 20 per cent, etc. In all cases it is wise to provide some surplus radiation for emergencies, so that less strain will be placed on the system during extremely cold weather.

TABLE 1.—*Temperatures to be maintained and length of pipe of different sizes needed to supply radiation for gravity-circulation hot-water systems.*

[Steam-heating systems take three-fifths of the length of pipe here stated.]

Temperatures to be maintained.	Radiation for each 1,000 feet of glass or its equivalent (square feet).	Pipe required to supply this radiation (linear feet).			Temperatures to be maintained.	Radiation for each 1,000 feet of glass or its equivalent (square feet).	Pipe required to supply this radiation (linear feet).		
		1¼-inch size.	1½-inch size.	2-inch size.			1¼-inch size.	1½-inch size.	2-inch size.
35° to 40° F......	191	438	382	305	55° to 60° F......	350	803	700	560
40° to 45° F......	225	516	449	360	60° to 65° F......	401	920	801	641
45° to 50° F......	262	602	525	420	65° to 70° F......	460	1,057	921	737
50° to 55° F......	303	696	607	486	70° to 75° F......	583	1,339	1,166	933

Table 1 is based on the use of 1¼, 1½, and 2 inch wrought-iron or steel pipe, as these are the standard sizes used for the radiating coils in greenhouse heating. In the early days of hot-water heating it was the custom to use cast-iron pipe 3½ or 4 inches in diameter. Many old houses, are to be found with cast-iron pipe of this description in their heating coils, but in modern construction the smaller wrought-iron or steel pipe is almost universally used.

The amount of radiation necessary for houses having less than 1,000 square feet of glass exposed can readily be determined by taking fractional parts of the amount necessary for each 1,000 square feet or by taking one-tenth of the amount neccessary for each 1,000 square feet and multiplying this by the number of hundred square feet of glass exposed. In practice, it is always desirable to use one size of pipe for the mains and another size for the radiating coils.

Table 2 gives the radiating surface for each foot of pipe of different sizes and the radiation that pipes of given sizes will supply. By the use of this table the amount of radiation in the mains can be calculated and this subtracted from that to be supplied in the coils. In most cases it is a good plan to figure the radiation needed and supply it in the coils, disregarding that supplied in the mains.

TABLE 2.—*Sizes of flow pipes for various radiation requirements.*

Flow pipe.	Radiation in each foot (square feet).	Radiation supplied (square feet).		Flow pipe.	Radiation in each foot (square feet).	Radiation supplied (square feet).	
		Steam.	Hot water.			Steam.	Hot water.
1¼-inch size	0.434	90	80	4-inch size	1.175	1,200	900
1½-inch size	.494	140	130	4½-inch size	1.309	1,550	1,150
2-inch size	.622	300	250	5-inch size	1.455	1,875	1,400
2½-inch size	.753	460	350	6-inch size	1.739	2,700	2,100
3-inch size	.916	670	500	7-inch	1.966	3,700	3,000
3½-inch size	1.055	920	700				

As an example, suppose that a certain house requires 350 feet of radiation to maintain the desired temperature and that it is the purpose to use 2-inch radiating pipes. By referring to Table 2 it will be found that a 2½-inch flow pipe will supply this amount of radiation. If the house is 50 feet long and the main is to be carried the length of the house the amount of radiation in 50 feet of pipe of this size may be deducted from the amount that must be supplied by the radiating coils. According to the table 50 feet of the 2½-inch pipe contains 37.6 square feet of radiation, and this subtracted from 350, the total amount for the house, leaves 312.4 feet to be supplied by the radiating coils. Each foot of 2-inch pipe has 0.622 square foot of radiation; hence, 312.4 divided by 0.622 gives 502, the number of linear feet of 2-inch pipe that must be installed to supply the proper amount of radiation. It is, however, better practice in most cases to install the correct length of radiating pipe to heat the house, disregarding the radiation supplied by the mains.

HOT-WATER BOILERS.

Many types of hot-water boilers are available for gravity hot-water heating systems, but the cast-iron sectional boiler is largely employed in plants requiring not over 10,000 feet of radiation. Some manufacturers recommend two or more boilers for this amount of radiation. In the larger plants steel boilers are usually employed, these being either of the ordinary fire-tube type or in some cases the

Scotch Marine. In some of the later and more up-to-date plants water-tube boilers fitted with mechanical stokers are employed, these plants being as economical as those of high-grade central, power stations. The type of boiler should be adapted to the conditions rather than selected because of its being of any particular type or material. For the best results the boiler should have a greater rating than is theoretically required to maintain the desired temperature. In planning the heating system, the first step is to determine the amount of radiation needed to maintain this temperature. As a rule, a boiler having a rating in feet of 20 or 25 per cent more than the radiation required for the house will be found satisfactory. This excess will allow for differences in fuels, poor draft, and other factors. In greenhouse practice it is often impracticable to have a fireman in constant attendance, and a boiler that is somewhat larger than is absolutely needed for the work will usually give more satisfactory results than a small one that must be forced.

In small houses it is particularly desirable that the boiler be larger than is theoretically required. Many steam fitters make a practice of installing boilers having at least 200 feet greater rating than the radiation required for the house. In larger plants this margin is made much greater.

CHIMNEYS.

If satisfactory results are to be secured from the heating system the boiler must be supplied with a chimney of proper capacity. The boiler is usually fitted with a smoke-pipe opening sufficiently large to carry off the products of combustion, and if a flue be built or stack erected with the same cross section as the fitting on the boiler and of such height that it will be above near-by objects, such as trees and buildings, the results will be satisfactory. Prof. R. C. Carpenter, of Cornell University, has worked out a table giving the sizes and heights of chimneys adapted to boilers of various sizes. (See Table 3.) The figures are in inches, giving the diameter of the flue if it is round, or along one side if it is square.

TABLE 3.—*Sizes and heights of chimneys adapted to boilers of different ratings.*

Radiation rating of boiler (square feet).		Diameter of flue (in inches) for chimney of given height.					
Steam.	Hot water.	20 feet high.	30 feet high.	40 feet high.	50 feet high.	60 feet high.	80 feet high.
250	375	7. 4	7. 4	6. 7	6. 4	6. 2	6. 0
500	750	9. 6	9. 2	8. 8	8. 2	8. 0	6. 6
750	1, 150	11. 3	10. 8	10. 2	9. 6	9. 3	8. 8
1, 000	1, 500	12. 8	12. 0	11. 4	10. 8	10. 5	10. 0
1, 500	2, 250	15. 2	14. 4	13. 4	12. 8	12. 4	11. [illegible]
2, 000	3, 000	17. 2	16. 3	15. 2	14. 5	14. 0	13. 2
3, 000	4, 500	20. 6	18. 5	18. 2	17. 2	16. 6	15. 8
4, 000	6, 000	23. 6	22. 2	20. 8	19. 6	19. 0	17. 8
5, 000	7, 500	26. 0	24. 6	23. 0	21. 6	21. 0	19. 4
6, 000	9, 000	28. 4	26. 8	25. 0	23. 4	22. 8	21. 2
7, 000	10, 500	30. 4	28. 8	27. 0	25. 5	24. 4	23. 0
8, 000	12, 000	32. 4	30. 6	28. 6	26. 8	26. 0	24. 2
9, 000	13, 500	34. 0	32. 4	30. 4	28. 4	27. 4	25. 6
10, 000	15, 000	37. 0	34. 0	32. 0	30. 0	28. 6	27. 0

INSTALLATION OF THE GRAVITY HOT-WATER SYSTEM.

After the proper amount of radiation and the size and location of the pipes have been determined and the boiler capacity needed to supply this radiation decided on, the whole success of the heating system depends on the way it is installed. For those not thoroughly familiar with heating problems, it is better to secure the services of a trained steam fitter rather than to attempt the work with inexperienced help. It is best to locate the boiler so that its top is at a lower level than the radiating pipes in the greenhouse. While the system will work as long as the bottom fitting of the boiler is below the radiating pipes, and even when the boiler is higher than the radiation, it is best to follow the plan suggested. Boilers are tapped or fitted for pipe that is large enough to care for all the radiation the boiler will supply. Unless the boiler is much larger than is actually required, these pipes should be of full size until the first branch is reached.

In branching hot-water pipes, abrupt turns should always be avoided. The pipes should be carried in the most direct route to each junction point, using pipe bends instead of fittings wherever possible. Every short turn in a hot-water line retards the flow of the water, and the results obtained with the system are largely dependent on the care exercised in laying it out. As pointed out in an earlier paragraph, hot-water pipes must have a uniform grade or fall if good circulation is to be secured. If the pipes are uniformly graded, a fall of 4 inches in each 100 feet will give good circulation. The flow pipe leaving the top of the boiler is usually carried in a vertical direction to a point so high that there will be ample fall for the pipes to make the circuit of the houses and return with uniform grade to the bottom of the boiler. The distance between the top of the boiler and the point where the flow pipe starts in a horizontal direction varies according to conditions, but for large plants it is usually from 10 to 15 feet from the ground and in small houses just below the ridge of the house. The expansion tank as a rule is located in the boiler room and at a point somewhat higher than the highest point in the system. It is connected with the bottom of the boiler and fitted with an overflow, so that as the water expands it can rise into the expansion tank and finally overflow if necessity arises. This type is known as an open expansion tank.

Another kind, known as the closed expansion tank, is merely a steel tank holding about one-tenth the capacity of the heating system. It must be air tight and fitted with a safety valve set to operate at a pressure below that which would be dangerous to the system. It should be connected with the heating system from the bottom of the boiler, and this connection must be through the bottom of the expansion tank. This type of expansion tank can be located at any convenient point, but no valves should be placed in the line connecting it with the boiler. As the water expands it forces its way into the tank, compressing the air in the tank and putting the entire system under pressure. A typical arrangement of boiler, expansion tank, and radiating pipes is illustrated in Figure 12. In this sketch both types of expansion tank are shown, but in actual practice only one is used.

Where several greenhouses are to be heated from the same boiler the arrangement is usually such that a common header supplied by the main flow pipe from the boiler runs along the end of the houses, preferably in the potting shed or workroom, where it will be protected from the elements, and this pipe is gradually reduced in size in accordance with the amount of radiation supplied each house. A common return line is usually located underneath the floor, and this is gradually increased in size as it nears the boiler until it reaches full size at the house nearest the boiler.

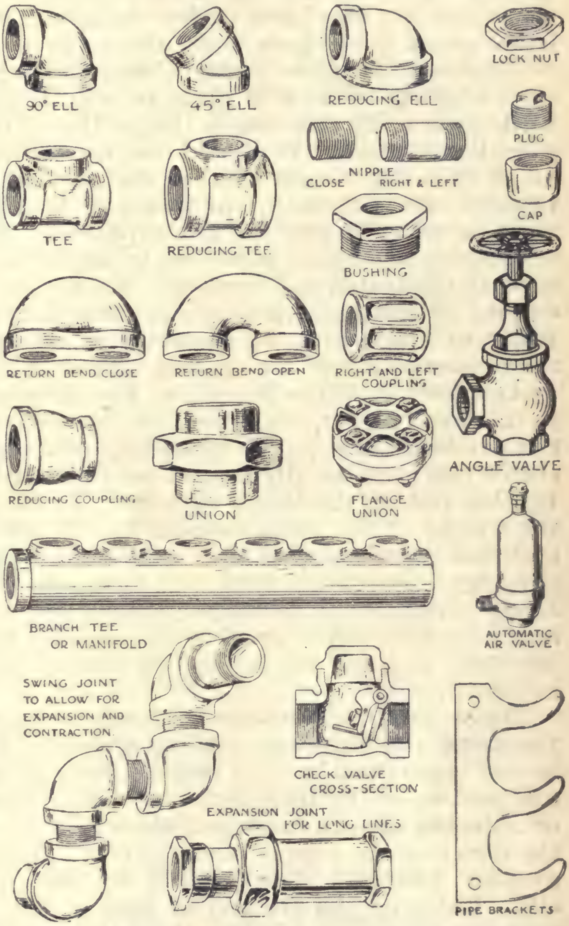


FIG. 13.—Some of the fittings used in the steam and hot-water heating systems of greenhouses.

LOCATION AND ARRANGEMENT OF THE HEATING COILS.

The location and arrangement of the piping system in the greenhouse must be planned to suit the particular house, and there are several well-defined arrangements to choose from. In general, the aim should be to secure uniform distribution of the heat and have the pipes out of the way. The usual arrangement is to have the mains or flow pipes overhead, with the radiating pipes under the benches or on the side walls or on the inside posts of wide houses. Pipes located along the side walls have a tendency to warm the cold air that enters through crevices, preventing its striking the tender plants. For small lean-to houses a good arrangement is to have the flow pipes overhead and branching into the returns at the end of the house away from the boiler, these being placed either on the side walls or under the bench. A suggested arrangement for this type of house is shown later (see Fig. 16). A system often used for small detached houses is to have the flow pipe under the ridge at such a height as to be out of the way and the return pipes placed on the side walls or under the benches. The arrangement is similar to that for the lean-to house, except that the main branches in two directions at the end of the house away from the boiler. The plans of the 10 by 50 foot house shown further on in this bulletin (see Fig. 17) illustrate this system. In other cases the flow and return pipes are both placed overhead with the flow pipe at a higher level than the return. In wide houses, fitted with benches, the flow pipes, usually two or more in number, are carried overhead, and the radiating pipes are arranged part on the outside walls and part under the benches. There is some objection to having the flow pipes overhead, as they cast some shade and are also more or less unsightly, therefore they are sometimes placed in conduits under the walks.

Overhead flow pipes must be supported every few feet to prevent their sagging. Pieces of chain or regular pipe hangers are usually used, these being attached to the purlins or other strong parts of the greenhouse frame. It should be remembered that pipe expands about 1½ inches in each 100 feet when heated from ordinary temperatures to the temperature of steam or boiling water, and provision must be made to care for this expansion. Swing joints, or regular telescoping expansion joints can be employed to care for this expansion, as illustrated in Figure 13. Flow pipes in conduits are usually carried on rollers, such as pieces of 1½-inch pipe slipped over other pieces of 1-inch pipe set crosswise in the conduit and embedded in the concrete walls of the conduit. These rollers allow free expansion and contraction of the flow pipe. Provision must be made somewhere in the flow line for this expansion and contraction, as in the case of the overhead flow pipe. Radiating pipes on the side walls or the center posts are usually carried on pipe hooks, and those under the benches rest on the bench supports. It should be remembered that the weight of the water necessary to fill the system is considerable and that pipes supplied with sufficient supports to keep them from sagging when empty may not have enough support when filled. Every pipe line in the heating system should be fitted with a valve, so it can be turned on or off as the necessity may arise. Although the first cost of good valves may be considerable, their installation is advisable.

Figure 13 illustrates some of the more important parts and fittings for steam and hot-water heating systems. The use of these fittings is well understood by most steam fitters, but some of them have been designed especially for greenhouse work. Either 90-degree, 45-degree, or reducing ells are employed where it is necessary to make turns in the direction the pipe is being carried. Right-angle turns are to be avoided wherever it is possible to use pipe bends or 45-degree ells. Reducing ells are seldom used in hot-water systems but may properly be employed in the return lines of steam systems. The same is true of reducing couplings. Tees must be employed where it is desirable to take two lines from one pipe, but in hot-water systems they should be so used that the supply is not attached to the fitting on the side of the tee, as the current of water is retarded when it strikes the side of the tee. The supply from the boiler should be attached at one of the end fittings of the tee, using the other two for the branches. The right and left threaded coupling with the right and left threaded nipple and a lock washer are employed in some cases instead of an ordinary union or a flange union. Bushings have a very limited use in heating work and should be employed only where their use is absolutely necessary. It is far better to use reducing couplings, but the best method of all is to plan the system so that reducing tees can be employed in branching the lines, thus avoiding the necessity for employing either bushings or reducing couplings. Plugs and caps are properly employed only for the purpose of temporarily closing lines where extensions are to be made. Return bends are much employed for the making up of coils of pipe for installation on walls where the pipe is only a few feet long. The open pattern is to be preferred where sufficient room is available for its use.

For greenhouse work the ordinary ground joint threaded unions are used for small-sized pipe, but for pipe above 2 inches in diameter the flange union is usually employed. Right and left couplings are employed for moderate-sized pipe, but these are seldom used for pipe larger than 2 inches. Branch tees are used where it is desirable to install several lines of radiating pipes in close proximity to each other, such as on the side walls of the house between the floor and the ventilator sash. These tees can not be used on both ends of long lines of pipe unless expansion joints are installed in each of these lines, as unequal expansion caused by some of the lines being hotter than the others will cause breakage. A method often followed to overcome this is to use one of these branch tees at one end of the radiating pipes, locating it so that the coils can be carried to a corner of the house where right and left hand ells are used to make the turn and running along the end of the house to a door where another branch tee is employed. The expansion of the pipe is cared for without placing a strain on the branch tees, but care must be taken to have the pipes far enough from the corner so they can move freely. The tee at one end of the line, usually the one near the door in the end of the house, is connected to the supply from the boiler through the tapping in the end of the tee, while the other tee is connected with the return system. Each radiating line should be fitted with a valve of the type best adapted to the conditions. The one shown in Figure 13 is known as an angle valve, but other types are available. Every set of radiating pipes, whether for steam or hot water, should be fitted with suitable means for removing air from the system. Such valves should be at the highest point in the system in which they are installed. Check valves are used in the return lines of steam systems to prevent the condensation from backing up in the system.

FORCED-CIRCULATION HOT-WATER HEATING SYSTEMS.

The forced-circulation hot-water heating system takes its name from the use of pumps to circulate the water through the mains and radiating pipes. The general arrangement of the pipes is the same as for the gravity system, except that the mains and radiating pipes may be run level if desired. Plants originally installed as gravity systems may oftentimes be greatly improved in economy and effectiveness by the installation of some suitable device for hastening the circulation. With forced circulation it is possible to maintain a given temperature with much less heating surface and usually with a lessened first cost. It should be remembered, however, that any device for hastening the circulation will necessitate the use of a boiler much larger than that theoretically required for the amount of radiation installed. The pump used may be of any suitable type, such as the rotary or the centrifugal, and may be operated by an electric motor, a steam engine, or a gas engine, or in cases where high-pressure steam is available for their operation the direct-acting steam pump may be used. It is not ordinarily feasible to use this type in small plants, as steam is seldom available for their operation.

Improved circulation can be had, however, through the installation just above the boiler of a simple and inexpensive circulator made of ordinary pipe fittings of the size of the flow pipe in which the device is installed. Figure 14 shows in cross section the essential parts of the circulator. It can be made by any steam fitter, and the cost of its operation is small, especially when a small electric motor is used. As will be noted in the illustration, the stuffing box consists of the bonnet of an ordinary globe steam valve from which the valve and stem have been removed and the shaft bearing the propeller slipped through in its place. The shaft should extend out of the stuffing box far enough to give room for the bearings, collars, and the driving pulley. The bearings may be supported by a bracket attached to the riser pipe. When a motor is used to operate the circulator, it may be mounted on another bracket on the riser pipe. In assembling the circulator care should be taken to have the pulley marked so the propeller will drive the water in the correct direction. A one-fourth horsepower motor will operate the device at sufficient speed to make a distinct improvement in the circulation in the system. When high speed, with consequent increase in the rapidity of the circulation is desired, more power may be necessary. The device is fitted with a by-pass, so that it can be used or not as desired. A type of pump frequently used in forced-circulation hot-water sys-

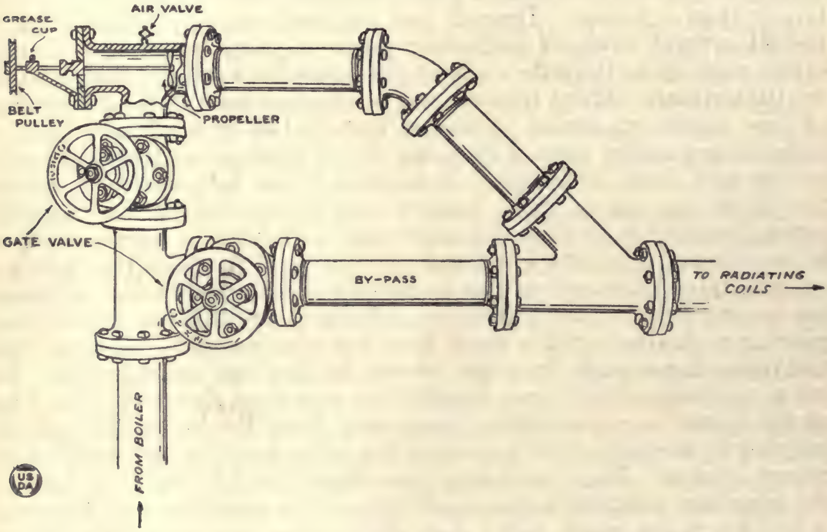


FIG. 14.—A simple hot-water circulator made of pipe and operated by power, such as an engine or a motor.

tems is illustrated in Figure 15, this particular pump being of the rotary type.

STEAM, VAPOR, AND VACUUM HEATING SYSTEMS.

When steam is employed for heating, Table 3 can be used for figuring the radiation and the size of the boiler and chimney, but under favorable circumstances these may be reduced to three-fifths or three-fourths those required for hot water. This reduction of radiation can be obtained by the use of smaller piping throughout, but the same general principle holds as to the arrangement of the mains and radiating pipes, while the returns connecting the radiating coils in the houses to the boiler can be of small size, as they carry only condensed steam from the heating coils. More care must be exercised in the design and installation of steam systems, as the changes in temperature and the expansion is greater than is usually the case with hot water. In low-pressure systems the circulation of the steam and the return of the condensation is by gravity, but where it is necessary to use high-pressure steam to get sufficient heat, steam pumps are usually employed for returning the condensation to the boiler, as otherwise it would remain in the heating coils. Many different types of steam-heating apparatus, such as vapor and vacuum and ordinary low-pressure systems, are in use. In any of these it is necessary that the system be kept free from air. In the vacuum and the vapor systems this is usually accomplished automatically and in the case of steam systems by either automatic or hand-operated valves. In installing any form of heating system it is wise to provide plenty of air valves for freeing the system from air, as good circulation can not be secured while there are air pockets.

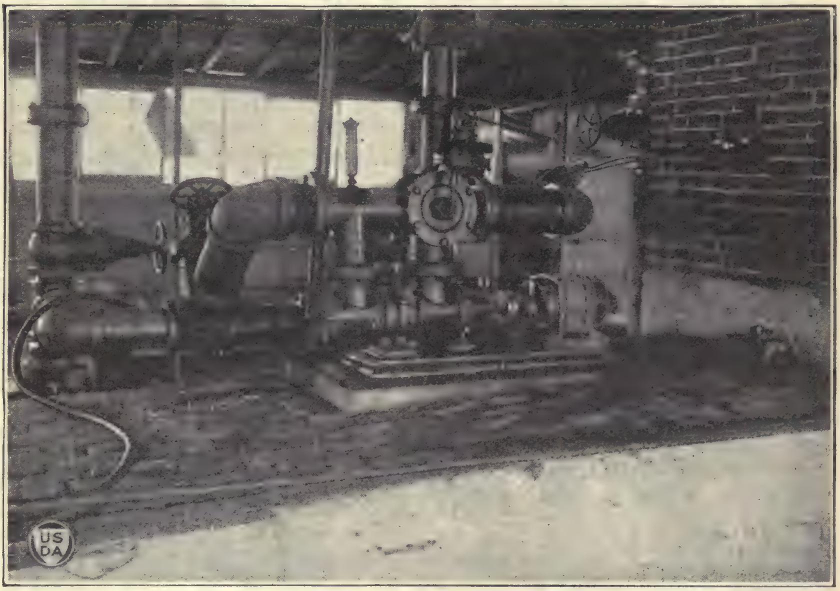


FIG. 15.—Rotary pump used in forced-circulation hot-water heating systems.

WATER SUPPLY.

Large quantities of water are required by greenhouse crops, and its supply should be one of the first considerations in locating and building a greenhouse. In many locations it is more economical to use a city supply, as its use makes unnecessary an extensive investment in wells, pumps, tanks, etc. Whatever the supply, its absolute reliability must be assured. When a private system is employed the water may come from any suitable source, and sufficient storage capacity should be provided to meet the needs of a day or two at least. This may be a tank on a tower, a pressure tank in the boiler room, or a reservoir on some near-by hill. The necessity for providing an absolutely reliable water system can not be overestimated.

The houses themselves should be piped so that all parts can be reached with a moderate length of hose. The supply pipes should be placed in position before the walks are laid, as it is much easier to perform the work at this time. Water pipes should not, however, be placed under concrete walks, as this necessitates breaking up the concrete when making repairs.

For many greenhouse crops overhead irrigation systems can be installed to good advantage, the use of such a system usually lessening the time spent in watering the crops. The necessary piping with inserted nozzles and other fixtures making up these systems can be installed on the pipe posts or other parts of the greenhouse structure, and the work can be done when the greenhouse is built, or if this is not practicable it can be performed at some later time.

BENCHES AND WALKS.

Greenhouse benches are expensive to install and unless of the best materials are short lived. Benches of durable construction, such as those with pipe legs and cast-iron supports and bottoms, or with iron frame and tile bottom, or of concrete, are durable but their cost is high. Wood benches are fairly satisfactory if made of cypress or other durable wood. At the present time there is a tendency to dispense with benches wherever it is possible to do so. Growers are finding that it is possible to grow many crops in ground beds, and the modern greenhouse, especially the vegetable house, is an inclosed area with only enough space occupied by walks to make it possible to handle the crops. For crops such as roses and carnations, where it is desirable that the plants be above the walks, in order that the crop may be more easily handled, this is often accomplished by either depressing the walks or by putting concrete curbs some 2 or 3 feet high along the sides of the walks and filling the beds with soil. The same results can be obtained by using boards along the walks, but such an arrangement is of a more or less temporary nature.

Greenhouse walks may be of any suitable material, such as cinders, brick, or even earth, but concrete walks are best, as these readily serve as a very satisfactory track for trucks and wheelbarrows used in handling material in the house. As little space as convenience permits should be devoted to walks, since it costs just as much to cover and heat the area occupied by walks as that in crops.

SOME GREENHOUSES SUITABLE FOR THE BEGINNER.

The greenhouse plans given on the following pages are submitted only as suggestions, for the plans can be modified to suit conditions. All the houses suggested are practical structures and well adapted to many uses, but modifications to suit the location and the particular needs of the individual can readily be made. The materials used in their construction can be varied also.

A LEAN-TO HOUSE.

The house shown in Figure 16 is a simple, inexpensive structure that can readily be built against some existing building. It is 6 feet 8 inches wide, or wide enough to make room for a walk 2½ feet wide and a bed 3½ or 4 feet wide. The house shown is 48 feet long, but it can be shortened or lengthened as desired. The house may be built as illustrated or the walk may be excavated to such a depth that the natural surface of the ground will be the right height to be used as a bench. This method will make the whole structure lower and will possibly lessen the cost. As figured, the house is constructed with concrete foundations and side walls, into which are embedded 2-inch iron-pipe posts fitted with special post top fittings to which is attached a wooden gutter. The construction can be modified so as to use wooden posts or to use the angle-iron eave-plate type of construction. The materials entering into the construction of such a house are simple and can be secured from firms making a specialty of such equipment.

LAYING OUT AND ERECTING THE HOUSE.

A lean-to house should have a southerly exposure, as otherwise it will be shaded for a considerable portion of the time. If built as a supplemental source of employment, when it is to receive but a portion of the operator's time, the location must be an accessible one. If the house is to be heated from some existing plant, the location must be such that this is possible. The laying out of greenhouses is similar to the laying out of other structures, and any good mechanic can readily perform the work.

The necessity for thorough workmanship can not be overemphasized. Success or failure with the house is determined largely by the way it is built. The setting of the pipe posts and the pouring of the concrete around them are matters that require painstaking care. It is best to excavate the trenches for the concrete, set the posts in position, bore holes of the proper size in the plate, slip it over the top of the posts and block it at the proper height, then attach the post top fittings and the gutter, lining it up and securing it in position before pouring the concrete in the forms previously prepared.

The placing of the ventilators, sash bars, glass, and other parts of the structure is in accordance with the suggestions made in earlier portions of this bulletin, to which the reader is referred.

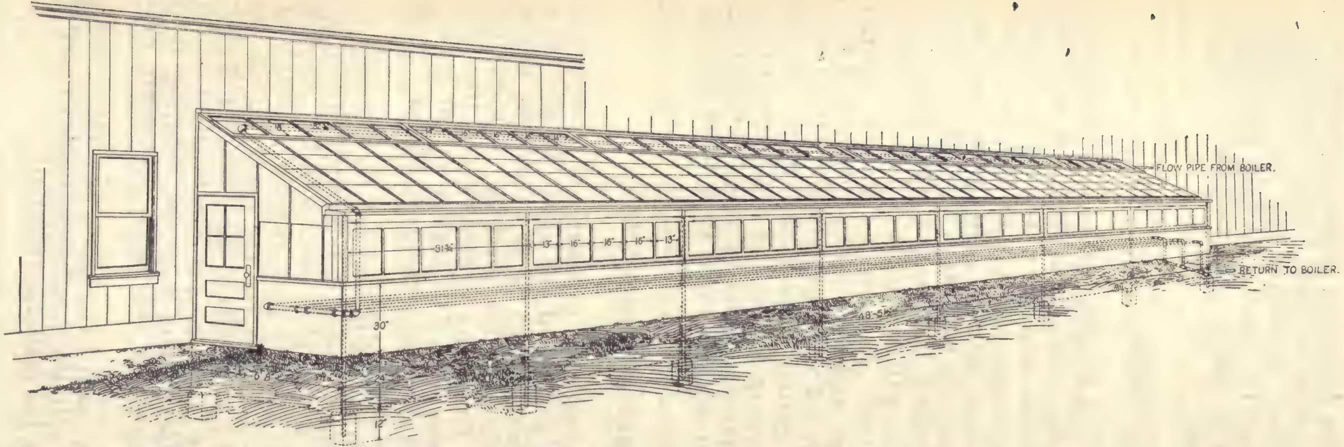


FIG. 16.—A lean-to greenhouse built against a building. This house is 6 feet 8 inches wide and may be made any reasonable length.

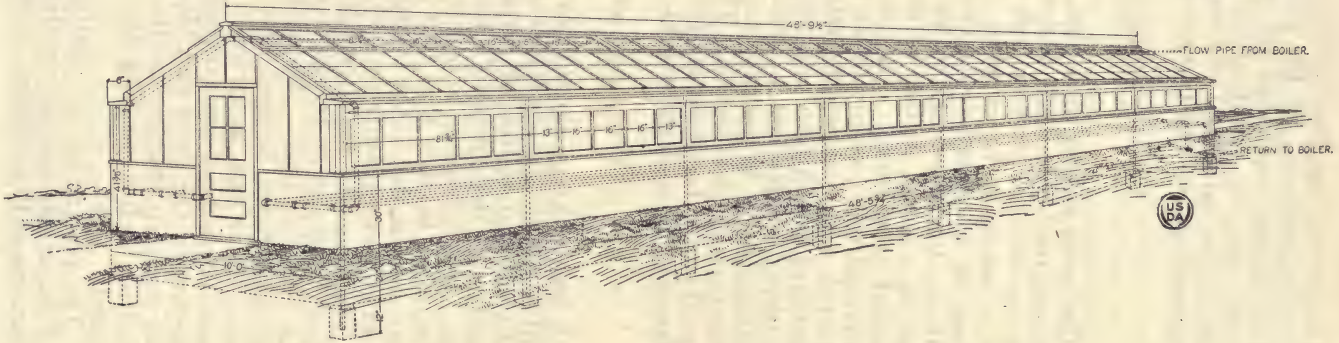


FIG. 17.—A 10-foot detached house well suited to the needs of the beginner.

THE HEATING SYSTEM.

The house may be heated in any one of a number of ways, but a gravity hot-water system is suggested as being both simple and efficient. The heat may be supplied either from a separate boiler located in a separate inclosure at the end of the greenhouse or it may be supplied from a boiler used for other purposes, such as the one serving the residence. In either case the pipe shown in Figure 16 entering the house near the ridge will be attached to the line supplying the heat. As shown in this illustration the house has about 500 square feet of wall surface taken up by the portions made up of concrete and the wall against which the house is built. The amount of radiation that should be allowed for this surface must be determined after taking into consideration the tightness of these walls and whether the building against which the house is constructed is heated or not. If heated, less radiation will be necessary, but figuring on a basis of 4 square feet of this wall surface as needing the same amount of radiation as 1 square foot of glass, this area of wall will be equivalent to 125 square feet of glass surface. The glass surface in this structure as figured in the plans is approximately 500 square feet, disregarding that contained in the ends of the structure. The radiation needed for the house, which could be determined from Table 1, is given in Table 4.

In using Table 4 always take full-length lines of pipe, even though this may give a little more radiation than theoretically is necessary. For instance, suppose it is the purpose to maintain a temperature of 35° to 40° F. and it is desired to use a 2-inch pipe, by referring to Table 4, giving the linear feet of pipe necessary to heat this house, it will be found that 183 feet will be required. Three lines of 2-inch pipe, each the length of the house, will not give sufficient radiation; hence four lines should be employed. In cases where the length of pipe required is very close to that supplied by a given number of lines it would be all right to ignore a small discrepancy. In figuring the radiation for these small houses it is usually advisable to disregard the radiation supplied by the main or flow pipe.

TABLE 4.—*Temperatures to be maintained and length of pipe of different sizes needed to supply radiation for a lean-to greenhouse.*

[Dimensions, 6⅔ feet wide by 48 feet long. The radiation in the flow pipe is disregarded.]

Temperatures to be maintained.	Radiation for the 600 feet of glass or its equivalent (square feet).	Pipe required to supply this radiation (linear feet).			Temperatures to be maintained.	Radiation for the 600 feet of glass or its equivalent (square feet).	Pipe required to supply this radiation (linear feet).		
		1¼-inch size.	1½-inch size.	2-inch size.			1¼-inch size.	1½-inch size.	2-inch size.
35° to 40° F......	115	263	229	183	55° to 60° F......	210	482	420	336
40° to 45° F......	135	310	269	216	60° to 65° F......	241	552	481	385
45° to 50° F......	157	362	315	252	65° to 70° F......	276	634	553	442
50° to 55° F......	182	418	364	292	70° to 75° F......	350	803	700	560

The heating coils themselves may be arranged in a number of ways, but in the house shown they are placed under the bench. The main is usually placed overhead with the radiating pipes either under the bench, as shown in the illustration, or along the wall back of the bed, or partly in each location. The pipes should have ample fall and be uniformly graded so that good circulation will be secured.

A TEN-FOOT DETACHED HOUSE.

The small detached even-span house shown in Figure 17 is well adapted to the needs of persons for whom the lean-to house is not suitable and yet who want a small, simple, and inexpensive structure. This house can be constructed with low side walls about 8 inches thick, with the walk excavated below the surface, but as figured it is to be built entirely above ground. This house also can be modified to suit conditions and the needs of the owner. A good plan is to have a center walk 2 feet wide and two benches each 3 feet 4 inches wide. Whatever modifications are made in the size and shape of the structure, attention should be paid to the economical division of the space in the house. For houses fitted with benches there is no width between 10 feet and 20 feet that divides economically between walks and benches.

The house as figured has wooden gutters, but other types, such as cast iron or the angle-iron eave-plate construction, can be used. Likewise other materials than those suggested can be employed in the different parts of the structure.

There is nothing better than a gravity-circulation hot-water heating system for a house of this description. The amount of radiation for the house may readily be figured by referring to Table 1. Table 5 gives the lengths of pipe of different sizes necessary to maintain the house at various temperatures.

TABLE 5.—*Temperatures to be maintained and length of pipe of different sizes needed to supply radiation for an even-span detached greenhouse.*

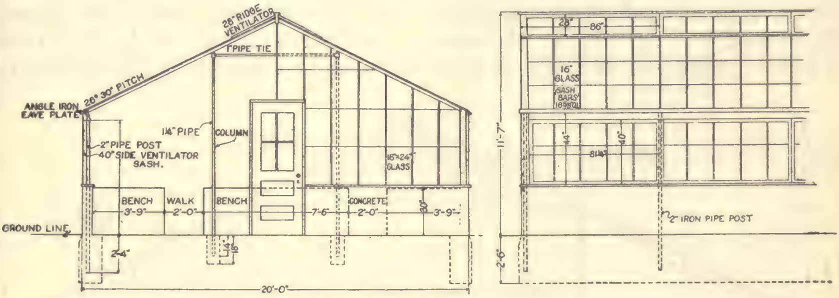
[Dimensions, 10 feet wide by 48 feet long. The radiation in the flow pipe is disregarded.]

Temperatures to be maintained.	Radiation for the 840 feet of glass or equivalent (square feet).	Pipe required to supply this radiation (linear feet).			Temperatures to be maintained.	Radiation for the 840 feet of glass or equivalent (square feet).	Pipe required to supply this radiation (linear feet).		
		1¼-inch size.	1½-inch size.	2-inch size.			1¼-inch size.	1½-inch size.	2-inch size.
35° to 40° F......	160.4	368	321	256	55° to 60° F......	294.0	674	588	470
40° to 45° F......	189.0	433	377	302	60° to 65° F......	336.8	773	673	538
45° to 50° F......	220.5	506	441	353	65° to 70° F......	386.7	888	774	619
50° to 55° F......	255.0	585	510	408	70° to 75° F......	489.7	1,125	980	783

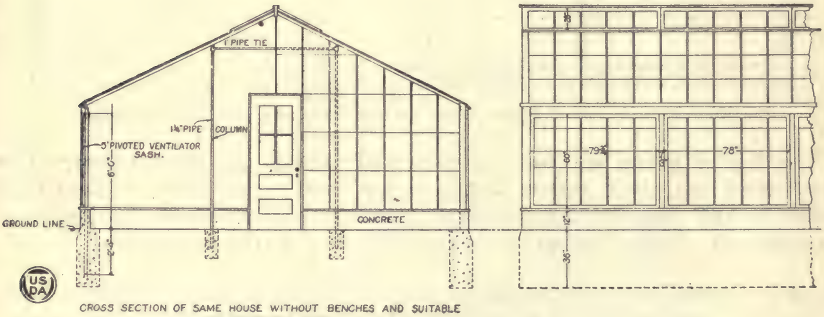
In Table 5 the number of lines of pipe of the size used that contains the number of feet of radiation nearest to that given in the table should be taken. It is always better to figure more rather than less radiation than is indicated as necessary by this table. For a house of the size specified the flow pipe should in most cases be placed under the ridge, this location making it possible to branch it in two directions at the end away from the boiler and to connect to the radiating pipes, which may be located under the benches, as shown in Figure 17, or along the side walls, either below the benches or part in either location.

A TWENTY-FOOT DETACHED HOUSE.

Figure 18 shows a 20-foot house of semi-iron construction with two rows of inside posts. This house could be built with one row of pipe posts through the middle and with braces from these posts to the purlins, as brought out in Figure 8, *B*. When constructed as shown in Figure 18 with two rows of pipe posts they are always tied together by pipe ties, the whole constituting what is sometimes termed the "giant arch." This house, with side walls about 8 inches thick, has space for two side benches, each about 3 feet 9 inches wide, two walks each about 2 feet wide, and a middle bench 7 feet wide. The exact width of the benches and the walks will be determined by the thickness of the walls, and the arrangement of the house can be varied to suit the needs of the operator. The suggested proportions are believed to be as good as any, as all these benches are about as wide as a workman can reach across and the aisles as wide as necessary for ordinary greenhouse needs. When the house is to be used for vegetable growing or for the production of other crops not needing benches, the type of construction shown in the lower part of



CROSS SECTION OF SEMI-IRON HOUSE FITTED WITH BENCHES AND SUITABLE FOR GENERAL WORK.



CROSS SECTION OF SAME HOUSE WITHOUT BENCHES AND SUITABLE FOR VEGETABLE HOUSE.

FIG. 18.—A 20-foot pipe-post, angle-iron, eave-plate house suitable for the production of either flowers or vegetables.

Figure 18 may be employed. The concrete walls are low, being but 12 inches above the surface of the ground, with the remainder of the space to the eaves occupied by ventilators, or part by ventilators and part by sash-bar and glass construction.

This plan is offered only as a suggestion as to the general construction of a house of this size and description. For such a structure wooden gutters are seldom used, as the angle-iron eave-plate type of construction is greatly to be preferred. For the grower who wants a medium-sized house for general greenhouse work it is difficult to find a type of construction that is better than the semi-iron house illustrated in Figure 18. Houses of this general type with two rows of inside posts can be built as wide as 50 feet and as long as necessary.

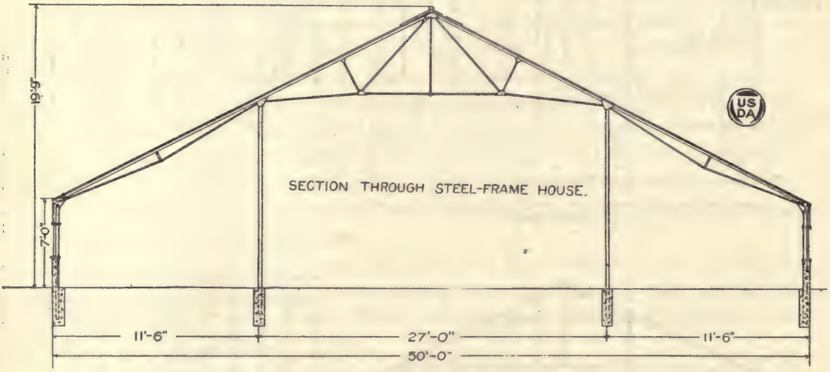


FIG. 19.—End of a steel-frame house 50 feet wide and any desired length.

The tables given in this bulletin will enable anyone to figure the amount of radiation, either steam or hot water, necessary to heat this house to any desired temperature. As an aid, however, in figuring the heating of this house the accompanying Table 6 is given.

TABLE 6.—*Temperatures to be maintained and length of pipe of different sizes needed for the greenhouse illustrated in Figure 18.*

[Dimensions, 20 feet wide by 100 feet long, containing 3,500 square feet of glass or its equivalent. The radiation in the flow pipe is disregarded.]

Temperatures to be maintained.	Pipe required to supply this radiation (linear feet).				Temperatures to be maintained.	Pipe required to supply this radiation (linear feet).			
	1½-inch size.		2-inch size.			1½-inch size.		2-inch size.	
	Steam.	Hot water.	Steam.	Hot water.		Steam.	Hot water.	Steam.	Hot water.
35° to 40° F......	802	1,337	639	1,067	55° to 60° F......	1,470	2,450	1,176	1,960
40° to 45° F......	944	1,573	756	1,260	60° to 65° F......	1,683	2,805	1,346	2,244
45° to 50° F......	1,102	1,837	882	1,470	65° to 70° F......	1,934	3,224	1,548	2,580
50° to 55° F......	1,275	2,125	1,020	1,701	70° to 75° F......	2,450	4,083	1,959	3,266

The figures given in Table 6 do not take into consideration the radiation supplied by the flow pipes. In a house of this size this is considerable, and if the house is of good construction it would be advisable to take it into consideration, reducing the radiating coils accordingly. The arrangement of the radiating coils will be determined by the interior arrangement of the house. If the house is to be fitted with benches, as indicated in the upper part of the figure, the main or flow pipes may be placed advantageously overhead, suspended from the purlins, with the radiating coils along the side walls or under the benches, or part of them in each location. For a vegetable house, where, as a rule, less radiation will be installed, the logical place for the radiating pipes is on the side walls.

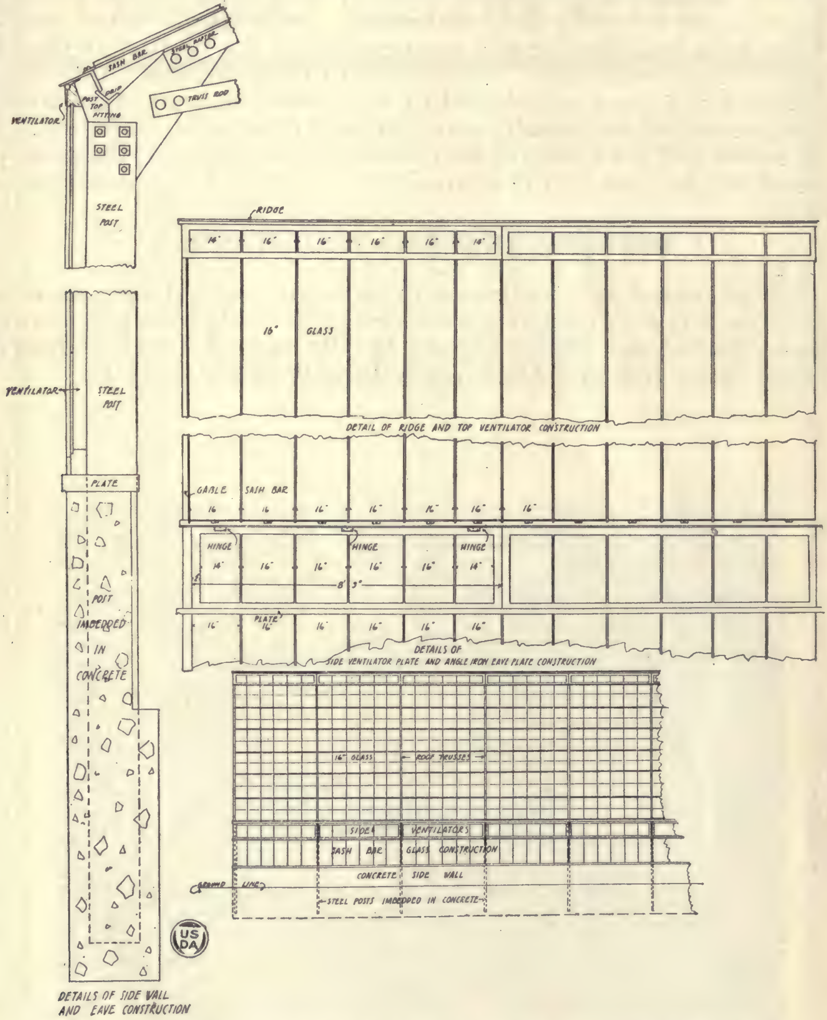


FIG. 20.—Details of construction of the steel-frame house shown in Figure 19.

A FIFTY-FOOT STEEL-FRAME HOUSE.

The construction of large steel-frame houses necessitates the employment of considerable engineering skill in designing, manufacturing, and erecting the structure. Figures 19 and 20 show the details of construction of a steel-frame house 50 feet wide, with two rows of inside posts. As figured, this house has 7-foot eaves, a 26½-degree pitch roof, and it may be as long as desired. These drawings are offered as a suggestion only, as the details of the construction can be changed to suit the conditions. As shown, the house has concrete walls 30 inches high above grade line and could be used without benches as a vegetable house or with them for the production of crops requiring such equipment. Such details as the height of the walls and the size and arrangement of the ventilators can be varied to suit conditions. The erection of houses of this type should be intrusted to men accustomed to such work, as these large structures are subject to specially severe strains from wind, snow, and ice and unless well built trouble may occur. Greenhouses of the general type shown in these figures are built as wide as 85 feet and as long as desired.

SPECIFIC INFORMATION GIVEN.

For additional information on the construction and equipment of the various types of forcing structures and for data on the forcing crops, the reader should address the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1319

COTTON DUSTING MACHINERY

DUSTING COTTON PLANTS with powdered calcium arsenate has proved to be the most economical and successful method of poisoning the boll weevil on a commercial scale. Success, however, depends largely on the use of suitable dusting machinery. This bulletin tells the prospective buyer how to select a type of dusting machine suited to the conditions and needs of his own farm, and one that should prove efficient and durable if given proper care. It supersedes Farmers' Bulletin 1098, Dusting Machinery for Cotton Boll Weevil Control, published in 1920.

Washington, D. C. May, 1923

COTTON-DUSTING MACHINERY.

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DEVELOPMENT OF MACHINERY FOR COTTON DUSTING.

WITH the establishment of the calcium arsenate method of control for the cotton boll weevil it has been necessary to develop a practically new industry—the manufacture of machinery that will apply this insecticidal dust to cotton in the manner required for successful results. Poisoning of cotton on a commercial scale was begun about 1917, and by the fall of 1919 enough knowledge of cotton-dusting machinery had been acquired to warrant a publication on the subject.[1] As much progress and rather radical changes along this line have been made since then, however, the present bulletin has been prepared so that all information to date may be available.

At the outset it was realized that specialized machinery was a necessity and that no other could be expected to yield successful results in dusting cotton plants. Years of experience in commercial poisoning have emphasized this necessity, and some of the most glaring failures have resulted from the use of makeshift apparatus. When cotton dusting was first undertaken, practically the only dusting machinery manufactured was that for treating truck and orchard crops. These machines were altogether unsuitable for use in the cotton field. Furthermore, the area infested by the boll weevil was so great and included such diverse conditions of cotton culture that a detailed study was required to determine the bearing of these conditions on the suitability of various types of dusting machinery. No one type has been found adaptable to all conditions, consequently an effort has been made to classify these conditions with special regard to the type of dusting machinery needed and to develop suitable machinery as rapidly as possible, priority being given to those districts that have seemed to require and deserve the earliest consideration. In this way various models of dusting machines have been developed step by step.

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[1] **Farmers' Bulletin 1098, United States Department of Agriculture, January, 1920.**

A mechanical division of the Delta Laboratory of the Bureau of Entomology, Tallulah, La., was organized at an early stage of the work and has been continued. This organization aims to develop new types of dusting machinery and to test and improve existing models. Several distinct types have been designed, constructed, and tested at the Delta Laboratory, and, when carried to a point of reasonable perfection, detailed descriptions and specifications have been furnished all interested manufacturers. Furthermore, any new developments of a fundamental nature are patented by the laboratory engineers and dedicated to the public, so that anyone may utilize, but not control, these features. Numerous manufacturers have modified these designs to conform to their methods of production, and their tentative models have been subjected to elaborate series of tests by the Delta Laboratory engineers, so that these machines may be perfected in every way possible before they are offered for sale. Undoubtedly these two lines of endeavor have not only aided in increasing the variety of machines available, but also have done much to increase their initial efficiency when placed on the market.

As was to be expected, some models developed in the earlier days have been discarded in favor of better equipment. Four years ago not a dusting machine on the market was suitable for treating cotton; now there are nearly 40 models, manufactured by over 20 manufacturers, and many more are being developed. The cost of these dusters has been somewhat high in the past, as is the case during the development of any new and complicated machine, but several have now become fairly well perfected, so that manufacturers can undertake quantity production. This will undoubtedly greatly reduce the cost. Furthermore, in the past it has been necessary to include in the price of these machines a rather heavy charge for salesmanship because of the pioneering effort necessary in introducing a new implement. This stage is now passing rapidly, and the cost of selling a dusting machine is decreasing sufficiently to permit a price much closer to the cost of manufacture. Even now these machines are much more reasonable in price than they were a year or two ago, and further reductions may be expected.

Other publications[2] furnish general instructions for poisoning, but certain principles involved in the process of dusting cotton influence the design of the machines and must be taken into consideration. These will be noted from time to time throughout this bulletin. One very important point, however, should be mentioned here. For successful dusting a time interval of hardly more than four days between poison applications has been found necessary as a general rule. Practical experience in the operation of the machines has shown that a certain allowance must be made for loss of time throughout the dusting period caused by unfavorable weather conditions and other circumstances. In all computations relative to the acreage capacity of any dusting machines, therefore, a 25 per cent loss of time has been included, and the seasonal acreage capacity of any one machine is rated as approximately three times its daily capacity. In other words, it will be able to treat this area every four days and still allow the loss of one day out of the four from some cause.

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[2] Farmers' Bulletin 1262 and Department Circular 162.

HOW TO SELECT DUSTING MACHINERY.

The first problem before the farmer planning to poison is the selection of equipment suitable for his particular conditions. Machinery can now be obtained to meet almost any condition, and the success of the whole dusting operation depends very largely upon choosing the right machine. Some of the more important points to be considered in deciding this matter are discussed in the paragraphs following.

CHARACTERISTICS OF FARM.

The size both of the individual fields or "cuts" and of the entire farm have a bearing on the size or type of machine to be used. Of course, the first question to be decided is whether the property is to be treated as a whole or whether the individual fields are to be regarded as separate units. In many portions of the Cotton Belt the crop is raised under the share tenant system. Some owners desire to buy large dusting machines with which to treat the entire property, regardless of tenant lines; others wish to purchase machines for each tenant, and naturally desire machines adapted to the acreage of the tenant. Under the discussion of machine types will be found an outline of the acreage capacity of each machine.

Other factors, however, may influence the selection of a machine more than the acreage of the field. If the dimensions and shape of the field are such that the rows are short, or if ditches, fences, or terraces make frequent turnings necessary, or if stumps and logs are present and must be avoided, the best machine will be one that can be turned easily and with the least damage to the cotton plants. For operation on rough, sloping hillsides, or heavily terraced land, where a machine on wheels might tip over, the type best adapted to avoid this difficulty must be chosen. Either hand or saddle guns can be used on such land without being placed at a disadvantage, but any machine mounted on wheels, to work under such conditions, must be well balanced, the weight placed as low as possible, and support against side-tipping provided by the animal, the driver, or both. If a machine operating entirely between two rows is considered for use under such conditions, one should be selected with the width between the wheels as narrow as possible or mounted on a single wheel, because this will reduce the tendency to tip over and will make the machine much more easily handled. Generally speaking, the two-horse or "cart" machine is more difficult to handle under these conditions, and is frequently altogether unsuitable because the width of its tread is fixed by the width of the cotton row, and its entire load is placed above the arched axle, thus making it top-heavy.

The method of cultivation is also important. The ridged type practiced in some districts makes it very difficult to operate any machine with two wheels running in a single middle, whereas this wheel arrangement is quite practicable in a field cultivated flat.

In planning to poison the farmer should, therefore, consider carefully the characteristics of the land he is going to treat. In many cases, on the larger farms, it will be necessary to purchase several different types of machines for a single property, using the larger, more rapid machines for the areas for which they are suitable, and providing other types to treat the remainder.

SUITABILITY OF MACHINE FOR LABOR AVAILABLE.

In selecting a dusting machine the farmer should consider who is going to operate it. On some farms there will be men who have had more or less mechanical training and who can operate the more complicated machines to better advantage than could the average cotton-farm laborer. Manufacturers are striving to build machines as simple in construction and operation as possible, but some machines are more complicated than others, and, as a result, require more skillful attention for their proper operation and upkeep, although this additional requirement may be counterbalanced by a corresponding increase in the speed and efficiency of dusting. One of the first machines developed was of a very large type, the dusting machinery of which was operated by a gas engine. Although largely abandoned, because of the inability of the average laborer to operate the complicated equipment satisfactorily, some machines of this type have been used for several years by comparatively skilled individuals with excellent results. The selection of a machine, therefore, should be governed to a certain extent by the class of labor available for its operation. Furthermore, in different districts laborers of the same class will have different ideas regarding certain points in the operation of the machine. For example, in some localities where riding cultivators are used extensively and the labor is thus not accustomed to walking implements, it is difficult to secure satisfactory operation of the one-mule type of machine, which requires the operator to walk, although in other districts this objection is not encountered. Then, too, in some places the average laborer objects strongly to wetting with dew, believing it prejudicial to his health, and under such conditions the use of hand guns has never proved really successful. It is to meet this objection that many of the one-mule machines are provided with shields which prevent the dew-laden plants from coming in contact with the operator.

The conditions under which the operator of the dusting machine has to work are not pleasant at best, and every effort should be made to secure a machine that will not impose an undue amount of work on him and the use of which will be as easy, simple, and comfortable as possible. With some types of machines the operator is forced to be in contact with the dust cloud at times, but whenever possible the nozzles should be so placed that the man has a minimum exposure to the dust cloud. Although under ordinary field operating conditions the poison dust is not injurious to human beings, if ordinary precautions as to cleanliness are taken, no one wishes to breathe it continuously or to have the skin coated with it.

This question of suitable labor for operating the machines enters into the problem in another way. As has just been mentioned, on the larger properties it is frequently necessary for the owner to decide whether the entire property shall be treated as a unit, or whether the individual tenants shall be provided with dusting machines adapted to their individual acreages, and each tenant required to treat his own crop. If the tenants are to do the work, only the simplest machines will be suitable, whereas, if the poisoning is to be handled by a force organized separately, it may be possible to secure individuals who can operate the larger machines; and, generally speaking, this separate organization for dusting will be found more efficient and profitable.

DAY OR NIGHT OPERATION.

The time of day or night when poisoning is to be done also has an important bearing on the type of machine to be used. **Dusting should be done when the air is calmest, whether it be during the day or at night.** As the presence of dew on the plants at night causes the poison to adhere to them better, and as night is usually the time of least air movement, this is the time when most poisoning is done. In some localities, however, trade winds blow during the night and the air is calmer during the day. Under such conditions the calmest portion of the day should be selected for the dusting. It is exceedingly important that the air be calm enough so that the dust cloud can be blown down through and among the cotton plants (see Fig. 1) and to permit the poison to settle over the plants.

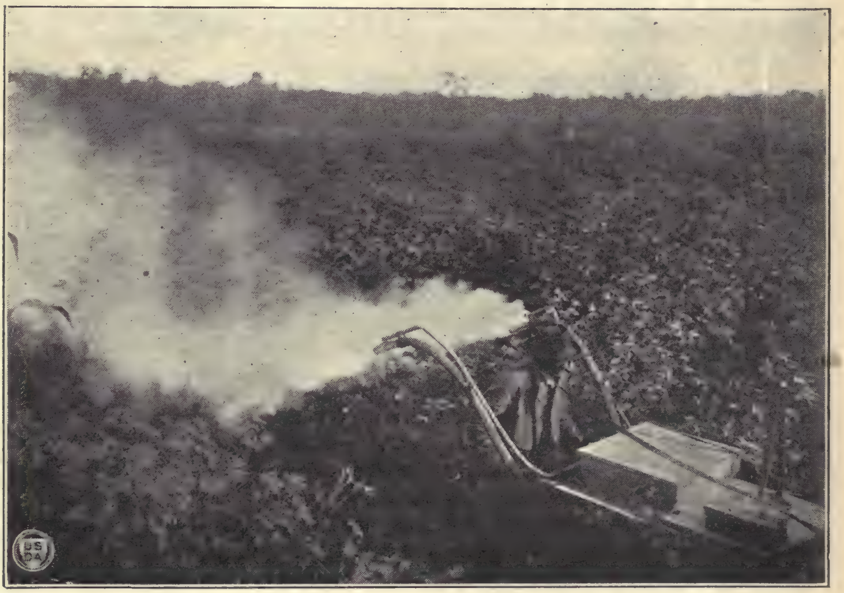

Fig. 1.—One-mule machine in operation, showing approved method of blowing dust downward through top of cotton plants toward the ground.

Night dusting, of course, makes the work more difficult, and some machines which can be run easily in the daytime are unsuited for night operation. Night applications have to be made under artificial light, which is a poor substitute for daylight. The light itself is more or less in the way and requires some attention. It is more difficult at night to watch the operation of the machine and to anticipate difficulties, and the repair work becomes much more complicated and troublesome when undertaken at night. Driving is more difficult, especially where stumps, logs, ditches, or other obstructions are shaded or hidden among the plants and weeds. In addition, the presence of the dew on the plants makes it necessary to provide some portions of the machine with suitable shields or guards, to prevent this moisture from entering and interfering with operation. As has been mentioned, the contact of the operator with the dew is also sometimes a complicating factor, and whenever possible machinery should be selected for night use that will provide the maximum amount of protection for the user.

In spite of all these difficulties attending night operation, however, it is almost always better to overcome them and to dust at night rather than to attempt daytime application; indeed, day applications can be recommended only where night winds prevail.

CHARACTERISTICS OF CALCIUM ARSENATE.

Only dry powdered calcium arsenate is recommended for boll-weevil control, and the characteristics of this material are such that dusting machinery of special design and construction is required for handling it. Whenever possible, a prospective purchaser should require a demonstration of a machine, to assure himself that it will distribute the poison properly. Calcium arsenate is exceedingly fine and inclined to be sticky, especially at night when there is much moisture in the air. As it packs quickly when subjected to a little vibration, agitators or stirring devices must be provided to guard against this and to insure a uniform delivery. Every dusting machine is equipped with some sort of a feeding device intended to regulate the amount of poison blown into the air. This device should be so constructed that it will give an even rate of discharge of dust for any period of time at any setting of the feed gauge, and will not clog or otherwise fail to operate under any condition. It is especially important that the dust delivery be regular at any position of the feed-adjusting lever, from complete cut-off to a maximum feed of about 25 pounds to the acre.

The amount of poison the hopper will hold at one filling is a matter of great importance, for it is very desirable to reduce as much as possible the frequency of filling the hopper without unduly increasing the weight or size of the machine. The volume of different brands of calcium arsenate varies somewhat, but the standard types range between 80 and 100 cubic inches to the pound; if, therefore, the dimensions of the hopper are known, its approximate capacity can be computed in pounds.

In examining a machine with a view to purchase, the farmer should remember that this sticky quality of calcium arsenate is dangerous from the time the material is put in the hopper until it is blown out of the nozzle. He should therefore follow its course through the machine carefully and see that at every step due care has been taken to prevent packing or clogging, and that all parts handling the dust are readily accessible for cleaning. The distributing tubes and their connections should be smooth inside, without any square corners to catch and hold the dust and without short bends to interfere with the free passage of the dust-laden air.

TYPE OF DUST CLOUD REQUIRED.

A very important feature of the dusting operation is the method for bringing the poison in contact with the plants. Spraying is an old operation and nearly everyone is more or less familiar with it, whereas the use of dry or "dust" applications is more recent and less known. The two operations, nevertheless, are fundamentally the same. In spraying, the poison is mixed with water just as thoroughly as possible and distributed over the plants. In dusting, air is used instead of water, and the poison should be mixed with it just as thoroughly to secure as complete a distribution; consequently it is important to have a machine that will separate the particles of poison and mix them thoroughly with the air. A good way to test this is to pass the hand under the nozzle and note the condition of the dust as it is blown out. If the machine is operating properly, the dust will be thoroughly mixed with the air and broken up into the finest possible particles. If lumps or small pellets are found, these represent so much waste material and correspondingly reduce the effect of the poison.

One advantage of dusting over spraying is that the spray will not float in the air to any great extent, and it is necessary to depend entirely on delivering it directly on the plants. The most successful dusting operation, on the other hand, creates a cloud of dust behind the machine which fills the air like a fog, drifts among the plants, and settles upon them from top to bottom, covering every particle of exposed plant tissue. To secure such a dust cloud is comparatively easy under really favorable dusting conditions, when the atmosphere is calm and contains sufficient moisture to cause the dust to hover for a long time wherever it has been delivered; but such ideal conditions occur only occasionally and are not the average conditions under which the farmer must operate in dusting his crop; consequently the most valuable machine is the one that will thoroughly dust the plants under the most unfavorable conditions.

Since the poison has a greater tendency to blow away when released above the plants than when actually blown into the tops of them, and since it is also exceedingly important to dust the upper portion of the plants, regardless of how high they may be, a considerable range in the elevation of the nozzles is essential. In the case of the cart type of machine, or any other machine straddling the rows, the tops of tall plants are bent down to the level of the nozzles, and it is not essential that these be subject to elevation much above the level of the machine platform; but in those machines which run between the rows it is very important to have the nozzles subject to elevations ranging from 18 inches to about 72 inches.

Some machines have been so designed that, when the nozzles are elevated to their maximum height, they will swing so that the dust is blown out horizontally to the rear. Such machines will not do efficient dusting, and the nozzles should be so arranged that when they are elevated to their maximum height they will still deliver the dust somewhat downward into the plants and thus prevent the breeze from blowing the poison away above the plants. Furthermore, the air blasts from the fan should be strong enough to force the dust cloud down through and between the plants to the ground from the highest elevation of the nozzles.

With some machines provision has been made for adjusting the distance between the nozzles so that these will fit different row widths, but, especially in machines of the larger type, this is of comparatively little importance.

In fact, except where two-row planters are used, the row widths vary so greatly in even a single field that it is impossible to keep the nozzles adjusted so as to put them directly over the rows. To meet this difficulty, the nozzles of many of the machines have been designed so that the dust-laden air is spread widely in a fan shape in leaving each nozzle, the clouds from the different nozzles thus uniting very quickly into a solid dust cloud extending across at least the width of the machine. In this way every particle of the plant is dusted, whether or not it is subjected to a direct blast from the nozzle.

Incidentally, it is exceedingly important that the farmer who is planning to poison shall know just what an efficient and thorough dusting of his plants looks like. Unfortunately, this is something which can not be visualized from mere verbal description, and even photographs fail to show the true appearance. The best suggestion is that everyone arrange to see one of the motion pictures which have been prepared to show the operation of dusting. These pictures were made by the Department of Agriculture and are available for free distribution in so far as the supply of sets of films will permit. They show the appearance and behavior of the dust cloud far better than words can describe them.

DURABILITY OF MACHINES.

No farm implement can be considered a success unless it is sufficiently durable to meet every condition under which it is to operate. As a rule, operators of cotton-dusting machines know little about mechanics and often are more or less indifferent regarding the upkeep of any machinery as long as it continues to run. To be a success, therefore, a machine must be of sturdy construction and good materials, with all parts readily accessible for repair or adjustment. This need, of course, is accentuated by the fact that most of these machines are used at night, when a breakdown or any need of repair becomes a much more serious problem than it would be in the daytime. In addition, boll-weevil control is always an emergency operation. The weevils are not controlled by a single application, but by keeping the cotton plants poisoned continuously over a certain period of time, and any interference with this schedule may easily cause the loss of control and the failure of the entire season's operation. Under such conditions, the breakdown of a machine may be disastrous. It is economy, therefore, to pay a little extra, if necessary, and get a machine that is thoroughly strong and durable as an insurance against such a possibility.

In the past many machines have been built along somewhat the same lines of construction as those used for orchard and truck-crop dusters, and when these were introduced into extensive field service under the conditions of continuous operation and rough handling encountered in the cotton fields, they did not last. Many broke down in less than a season, and others were ready for the scrap pile after operating a single season. There is no reason why the farmer poisoning his cotton should be forced to buy new dusting machinery every year, and the production of machines has now developed to the stage where the farmer can demand and secure a machine that will be just as durable as any other implement he has on the property. Formerly, the most that could be expected of any available hand gun was that it would last through a single season, but now there are models on the market that can be reasonably expected to last three or four years. The first large-type machines lasted only one or two years, but many of the present models undoubtedly will do satisfactory work for at least five years, if given a reasonable amount of care. The farmer should demand a machine which not only will give efficient service at the outset, but also will continue to give this service over a period of years.

GENERAL CHARACTERISTICS OF DUSTING MACHINES.

Before discussing the different types of machines, it is well to point out certain fundamental characteristics which are found in all machines, a knowledge of which will aid in a more complete understanding of the different types.

The dusting machinery proper consists of a fan or blower, a dust container or hopper, and the feeding mechanism. The arrangement of this combination varies in machines of different makes, but the aim in all of them is to have a hopper that will hold as much poison as can be transported conveniently, a feeder that will regulate the dust discharge at any quantity desired, and a fan that will produce a blast or current of air sufficient to deliver the dust at the required points.

At present three different kinds of air currents are used in dusting machines: First there is the "velocity" current, in which the volume of air is comparatively small but moves at a high rate of speed; second, the "volume" current, in which a large volume of air moves at a moderate speed; and third, the "intermittent" current, in which the air current is produced intermittently, as from a bellows. The third type is unsuited to cotton dusting, since this operation demands a continuous flow of dust to produce the cloud. All really successful cotton-dusting machines are equipped with either the volume current or the velocity current.

Two different methods are used to move the dust to a point where it will be taken up by the air current. In one the dust is delivered by the feeder directly into the air line beyond the fan, while in the other the dust is fed into and through the fan either from the center of the fan or through the rim of the fan housing. Many claims are made by various manufacturers regarding the relative efficiency of these two systems. Those who feed the dust through the fan claim that the dust is broken up and better mixed with the air because of this fact; but, as far as present experience goes, there is apparently little or no choice between the two methods and both operate successfully.

There are many types of feeding devices; and, in fact, almost every model of machine has a device which differs somewhat from all others. Based on the fundamental principles involved, however, these feeders may be divided into comparatively few classes, and all tend to regulate the quantity of dust delivered and to carry or crowd it to a point where it is caught by the current of air. The following are some of the most common classes:

The brush feeds usually consist of some form of rotating bristle brush. They crowd the dust in front of the bristles and force it through an opening, the quantity going through being controlled either by changing the speed of the brush or the size of the opening.

The auger feeds usually operate by catching the dust in a spiral auger and forcing it along into the air current. They are regulated either by changing their speed or by changing the size of the opening which allows the dust to flow to them.

The whirling-disk feeds operate by throwing out by centrifugal force the dust which falls on them. They have a constant speed, and control of the quantity of dust is gained by varying the size of opening which allows the dust to flow from the disk.

The wire-cage or wiper feeds are found in a wide variety of shapes but are very similar in principle. They have some form of rotating or oscillating device which wipes or crowds the dust through an adjustable opening. These wipers are usually of constant speed and depend on the adjustment of the opening to control the dust delivered.

The air-blast feed consists of a blast blown from the fan through the dust hopper itself and depends on this blast to pick up sufficient dust to create a cloud. Its only adjustment is in either varying the rate of fan speed or by an adjustable deflecting blade throwing the air current more or less against the dust in the hopper. So far this type of feed has proved exceedingly unsatisfactory, since it has never been found possible to get a uniform rate of dust delivery throughout the various changes in the amount of dust in the hopper, and such a feed should be avoided in buying machinery for cotton dusting.

The plain-valve feed was one of the earliest types developed, but has been very largely replaced by the more efficient designs. In this class the quantity of dust delivered is controlled by varying the size of an opening through which the dust is supposed to flow by gravity into the air pipe. It has never been found possible to secure a satisfactory and uniform delivery of calcium arsenate when dependence is placed entirely on gravity.

Roughly speaking, these various feeding devices may be classed into the " forced " feeds and the " gravity " feeds, the gravity type depending on the material dropping down without assistance through some sort of an adjustable opening, while the forced feeds in some way push the material through the opening in a constant delivery. The forced type of feed has proved far more satisfactory in cotton dusting and should be secured whenever possible; in fact, nearly all manufacturers have abandoned the gravity type and it is encountered very seldom at present.

Another important consideration in connection with the feeder is the fact that it should be readily adjustable to any desired rate of delivery, from complete shut-off to about 25 pounds per acre, as based on the dust delivery from the individual nozzles. This wide range will enable the operator, when he becomes more familiar with the technique of poisoning, to increase greatly the area covered by giving a heavier feed, thus increasing the dust cloud formed and treating a larger number of rows than those actually spanned by his nozzles at each trip, advantage being taken of the drift of the poison through the plants beyond the rows over which he has actually passed.

For calculating rates of feed the following method may be used: For each pound of dust per acre, each nozzle should deliver at the rate of 0.015 pound per minute. Thus a hand gun having only one nozzle should feed at the rate of 0.075 pound per minute to deliver 5 pounds per acre, or 0.375 pound per minute to deliver 25 pounds per acre. The cart machine, having 3 nozzles, should deliver three times these amounts.

One type of feeder to be avoided is that which permits the dust to fall through into the air duct when the fan is not in operation. Some machines have been constructed which leave openings for the dust to be jostled through when they are not operating, and these have caused much difficulty, because this dust will fall through into the air passage and often clog this solidly before the fan is started, thus making it necessary to take the machine apart and clean out this passage.

The power for running the dusting machinery is furnished in the following three different ways, governed by the size and type of the machines:

(1) Hand-driven machines, in which the dusting machinery is turned with a crank by the operator. The hand and saddle guns are in this class.

(2) Traction-driven machines, in which the machinery derives its power from the traction wheels through chains or gears. The so-called one-mule and cart dusters are in this class.

(3) Engine-driven machines, in which a gas engine is mounted on the platform and connected with the dusting machinery, usually by a belt.

The relative characteristics of these different types of power will be mentioned in the following discussions of the various machine models.

MACHINE TYPES.

As has been mentioned, there are many different models of machines, but these may be grouped into certain classes or types based on certain uniform characteristics. The following is a brief outline of these various types with a consideration of the capacity, advantages, and disadvantages of each type.

HAND GUN.

The smallest type of dusting machine is the one that is carried by the operator and cranked by hand. The trade name "hand gun" has been very universally adopted to describe this type. It is usually constructed of sheet metal, with the hopper and fan housing either together or separated, and with a simple set of gears or chains for transmitting power from the crank to the fan, agitator, and feeder. It is usually suspended from the shoulder of the operator by web straps, the method of strapping depending on the construction of the gun. Some are carried in front of the operator, resting on the abdomen, while others are carried on the side, resting on the hip. Experience has shown that the gun that is carried on the abdomen is usually the most comfortable to operate.

The weight and balance of the hand gun is a very important item. It should not only be sufficiently light to be carried without undue fatigue, but it should also be so balanced that the greater part of the weight will be as close to the body of the operator as possible and thus prevent any increase in the strain by leverage. For instance, the machines having the hopper of dust close to the operator are usually more easily carried than those with the fan housing intervening and the dust hopper farther forward, as guns of this latter type increase the pull on the shoulder straps. The weight of a hand gun with the hopper full of dust should not exceed 20 pounds, as this is all that can be carried without overburdening the operator. The hopper capacity of the various hand guns on the market ranges from 2 to 7 pounds of poison, and it is, of course, desirable to have it as large as possible without making the gun too heavy.

Several manufacturers have attempted to develop a hand gun with a bifurcated delivery line leading to two nozzles, for the purpose of dusting two rows simultaneously. These efforts, however, have been unsuccessful so far, since it has proved impossible to secure sufficient air blast to dust two rows thoroughly within the weight limitations of a hand gun. In so far as present machinery is concerned, therefore, no one should attempt to treat more than one row at a trip with a hand gun.

The rate of operation of a hand gun will, of course, depend largely on the endurance of the operator. As a rule, the average operator will be able to dust 1 acre an hour for the first hour or two and will then decrease rapidly in speed, until a rest is necessary after about three hours of operation. For this reason hand-gun operation is usually so organized that the dusting is done from daylight until about 8 or 9 o'clock in the morning, and then an additional hour or two is put in just before dark in the evening. In this way it has been found that an operator with one gun can take care of about 8 acres of cotton for the season. On the whole, it has been found that the hand gun is the least satisfactory of the various types of dusting machinery, primarily owing to the difficulty of operation, and it is seldom that satisfactory results have been secured when any considerable acreage is attempted with a number of hand guns. It is a good general rule not to attempt to treat more than about 25 acres in one organization with hand guns, regardless of the number employed, and another good rule is to use hand guns only when no other machine is suitable.

The advantage of hand guns over other types is largely their initial cheapness and adaptability for getting into places inaccessible to larger machines. Furthermore, hand guns are often necessary when the area to be treated is too small to justify the expenditure involved in the purchase of a larger machine.

The disadvantages of the hand gun are that they are exceedingly laborious to operate, and as a result the dusting is often poorly done;

many of them are fragile in construction and thus not sufficiently durable to withstand the hard knocks which they will receive; the operator must walk through the wet cotton, and when the cotton is very tall it is practically impossible to elevate the nozzle sufficiently to reach the tops of the plants. This last difficulty frequently has been overcome by using the hand guns from mule back, and a large amount of very effective dusting has been done in this way.

The various models of hand guns on the market are now offered for sale at from $8 to $18 each. Some of these will last only one season at most, but some of the better types will last for three or four years if given a little attention.

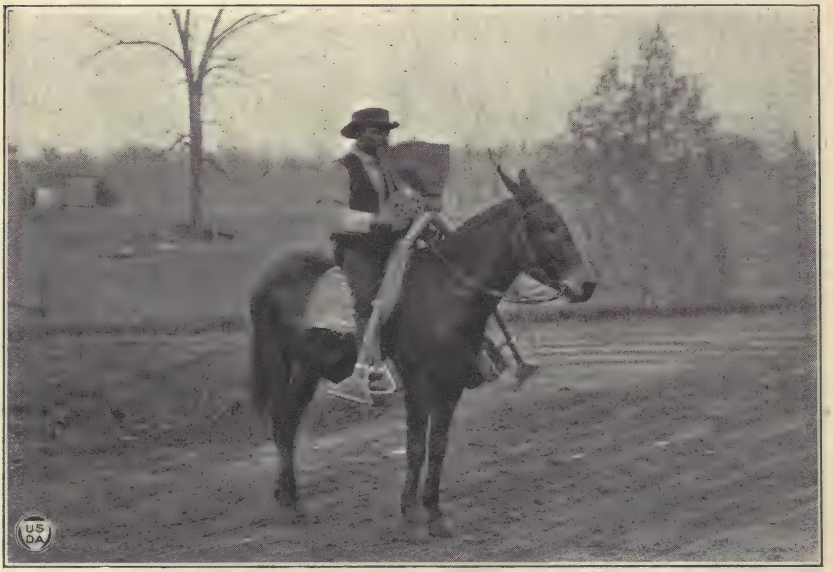

Fig. 2.—Saddle gun attached, ready for cotton dusting.

SADDLE GUN.

The saddle gun (Fig. 2) is somewhat similar to the hand gun in that it is light and operated by hand cranking, but, as the name indicates, it is designed to be carried on the back of a mule which the operator rides while turning the hand crank, and is usually attached in some way to a saddle. These guns have two nozzles, one extending down on each side of the mule, and it thus treats two rows at a trip. A saddle gun should dust about 15 acres in a day or night of operation, and thus should take care of about 40 to 50 acres of cotton for the season.

The saddle gun can be used under practically any conditions encountered in cotton dusting, is comparatively cheap, and the labor of operation is not great. Furthermore, it is exceedingly mobile and can be taken into places where no machine mounted on wheels could be used. It is not to be expected, however, that it will replace either of the larger types of machines and should be used largely as supplementary to them. So far it has proved impossible to construct a saddle gun that will create as good a dust cloud as can be secured with the larger machines, and, furthermore, the method of mounting the nozzles makes it very difficult to control their direction readily and thus to secure a thorough dusting of the cotton. In addition, the saddle gun is somewhat difficult to handle in saddling and unsaddling, and is awkward to fill with poison unless the hopper is detachable.

The only guns of this type on the market sell from $55 to $75, but it seems probable that future development will reduce this somewhat.

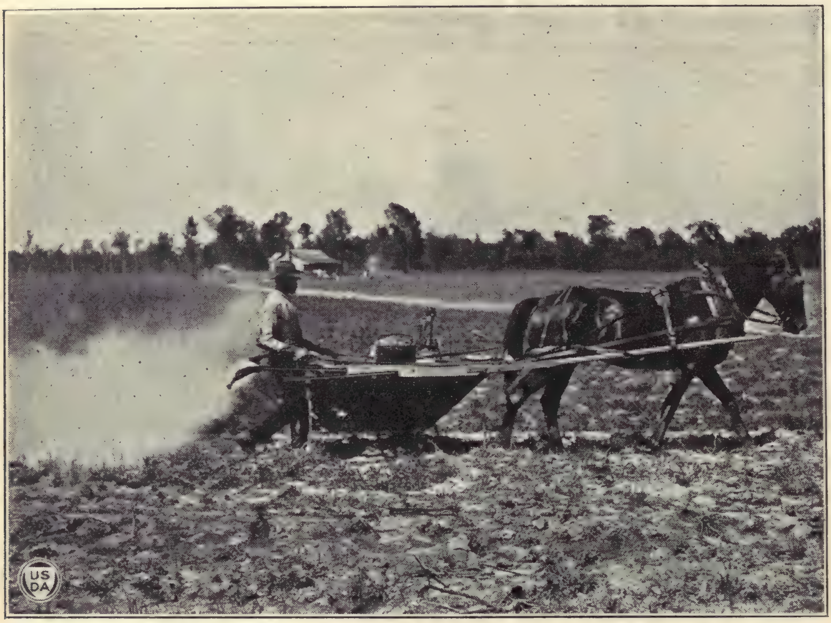

FIG. 3.—One-mule type of cotton-dusting machine, drawn by a horse, showing general construction.

ONE-MULE MACHINE.

The one-mule machine (Fig. 3), as the name implies, is drawn by one animal and dusts two rows at a trip. It derives its power from the traction wheels, and the operator walks behind it and usually steadies it by means of handles similar to those of a plow. As a rule it is built so as to work entirely between two cotton rows and has the nozzles extending behind and on each side of the operator. Some models have only one wheel and use shafts in guiding and steadying the machine, whereas others have either two or three wheels. Those with two wheels also have shafts, since their construction is much the same as that of the one-wheel machine. When two wheels are present the distance from outside to outside of the wheels should be not more than 14 inches, and any decrease of this distance is an advantage because it decreases the side sway and also reduces injury to the plant. The three-wheel machines usually have a singletree hitch and have a castor wheel or shoe in front, which acts as a guide. Since there are no shafts on this machine, it is entirely dependent on the operator to steady it by means of the handles.

The one-mule machines were first placed on the market at the beginning of 1921, and quite a number were used in that year. Of course some difficulties were encountered, but on the whole the splendid efficiency of this type was well proven. One of these machines will dust from 15 to 20 acres in a day or night, and will thus take care of from 50 to 60 acres for the season. It's principal advantage is that it permits simplicity of construction and also that it can be operated in almost any place where a horse or mule can walk. It is easy to turn around stumps and to turn at the row ends. Furthermore, it requires comparatively little artificial light for its operation, since it is practically entirely protected by the animal. The hopper, which holds from 20 to 45 pounds of dust in the different models on the market, does not require very frequent filling, and the labor of operating is not greater than that of any other walking implement. Its disadvantages are that in some places the laborers object to walking, and they are somewhat exposed to contact with the dew-laden plants. In addition, these machines turn over occasionally, but they are usually so constructed that no damage results from this. When a one-mule machine is first operated by a new farm hand it frequently seems cumbersome and difficult to guide, but the same laborer probably had at least as much difficulty the first time he tried to operate a turning plow, and with only a little practice he will be able to guide the one-mule machine with ease.

The machines of this type on the market sell for from $100 to $125 and should last at least five years with reasonably good care.

CART DUSTER.

The trade term "cart duster" has been adopted to describe the two-horse duster mounted on two wheels, with the driving power for the machinery furnished by these wheels. (Fig. 4.) The axle is of such length that it allows the wheel to run in the center of the rows, and is arched to clear the plants in the row being straddled. As a rule a 42-inch clearance will be found under the arched axle, and this will permit the dusting of plants of any reasonable height. This machine has three nozzles, one over the row being straddled and the others more or less over the rows on each side of the machine. The hopper holds from 25 to 65 pounds of dust in the different models on the market.

One of these machines will treat from 25 to 30 acres in a day or night and thus will care for from 75 to 100 acres for the season. It requires no effort on the part of the operator except to drive the team as he rides in a seat on the platform, and he is not exposed to the wet plants or to the dust cloud. Since the platform is usually about 44 inches from the ground it affords a high mounting for the nozzle, which is an advantage in dusting tall cotton. Furthermore, a barrel of poison can be carried on the platform, making it easy to refill the hopper without dismounting or going out of the field for a supply.

The disadvantages of this machine are that it is somewhat difficult to drive at night and that it requires a rather elaborate lighting equipment. It is also somewhat top-heavy owing to the high-arched axle construction and thus upsets rather easily on uneven or stumpy ground. On the whole this type of machine is best adapted for large open fields clear of obstructions. Numerous models of cart machines are on the market at prices ranging from $200 to $300, and as these are usually of very durable construction they should last for several years.

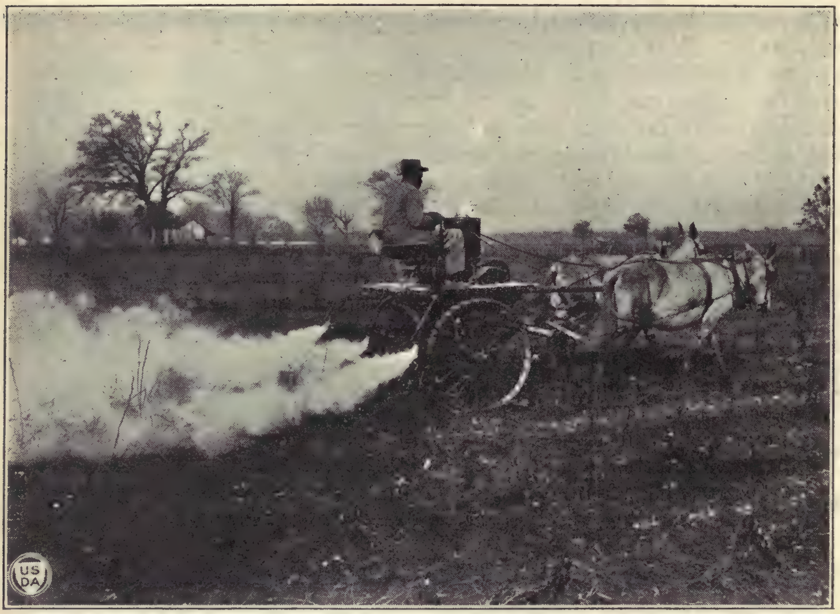

FIG. 4.—Two-mule or "cart" type of cotton-dusting machine, showing general construction.

POWER DUSTER.

The power duster consists of a four-wheel wagon with a dusting machine and gasoline engine mounted on the platform, which also carries the lighting equipment, an extra barrel of dust, and two men, one to drive and the other to operate the engine and dusting machinery. This duster, although usually having five nozzles and capable of treating 50 to 60 acres of cotton in a day or night, has not proved generally satisfactory for cotton dusting. It is heavy and cumbersome to handle and can be used to advantage only in very large open fields. The four wheels do much damage to the plants in turning. Then, too, more or less delay is caused by the necessity for repairing the machinery, not only because this type is naturally more complicated in construction but also because the vibration of the engine subjects the entire machine to a strain that is very difficult for such equipment to withstand. These difficulties have proved so serious that this type of machine has been practically taken off of the market. Furthermore, grave difficulties have been encountered with the five-nozzle distributing system, since no design has yet been constructed that would give a continuous flow of dust through such a large and complicated distributing system without frequent clogging. In addition, the very width of this distributor makes it exceedingly difficult to handle near obstructions, and frequent breakage results.

LIGHTING EQUIPMENT.

Owing to the necessity of night operation, the question of lighting equipment is very important; in fact, in the earlier days of dusting the operation was infinitely more difficult than now, because no really satisfactory lighting equipment had been found. Almost every conceivable type of lighting device was attempted and most of them proved unsatisfactory. For example, the various gasoline-vapor lights gave a good illumination, but no mantle would withstand the rough travel over the cotton fields. For the larger machines any type of coal-oil light proved insufficient. Finally, however, a very satisfactory light, using a compressed carbide cake as fuel, was developed. A special model of this light has been constructed for cotton-dusting machines, and is furnished by a majority of manufacturers as standard equipment with the larger machines. It is somewhat expensive, it is true, but it saves many times its cost each year in increased efficiency of operation. Anyone purchasing a cart type of machine is strongly urged to see that it is equipped with such a light at the outset. For the other machines, such as the one-mule and mule-back types, it is not necessary to have nearly such brilliant illumination. During the season of 1921 very satisfactory operation of the one-mule machines was secured by mounting an ordinary coal-oil lantern on them, while with the mule-back guns a carbide headlight, such as is sold for use on bicycles, can be used to advantage. In handgun work it is usually unnecessary to have any special lighting equipment, since most of this work is done in the early morning or late evening; but when such lights are desired, about the best that can be secured is a small carbide light worn on the head, such as is ordinarily sold for hunting purposes. The price of these different lights varies considerably. The large type, such as is used on the cart machine, usually sells for from $30 to $45. The bicycle headlight type can be purchased for from $2 to $3, and a very satisfactory cap light can be bought for about $1.50.

COST OF OPERATION.

The cost of operating the various dusting machines depends so completely on the conditions on the particular property, the efficiency of operation, the acreage allotments which can be maintained, etc., that it has been found practically impossible to give any definite figures on this subject that have a general value. Furthermore, the cost of the different machines varies widely, as does their durability. In the past it has been rather difficult to calculate the exact machine cost because of lack of definite information on which to base the depreciation charge that should be carried against the different types of machines. Now, however, with longer experience, more or less definite rules have been adopted by the various farmers engaged in commercial dusting. For example, with the better classes of hand guns it is customary to carry an annual depreciation charge of about 33⅓ to 50 per cent, while with both the one-mule machines and the cart machines a 20 per cent annual depreciation charge appears reasonable. In addition, the question of upkeep enters into the problem, and it is customary to charge from 5 to 10 per cent annually for the upkeep of the one-mule machines and from 10 to 15 per cent annually for the upkeep of the cart machines. This, of course, includes all repairs, adjustments, and replacements. As a rule the total cost per acre per application of the items of machine depreciation, machine upkeep, man labor, and mule labor will be from 20 to 25 cents with either the one-mule or the cart types of machines, whereas with the hand guns it will usually be somewhat higher. The saddle guns have not been developed to the point where any figures of value are available.

MACHINE OPERATION AND MAINTENANCE.

The best rule for the care and operation of any cotton-dusting machine is the "golden rule of common sense." Almost all of the machines now available will start out and perform efficiently for some time without any care whatever, but no man is going to get his money's worth out of his investment from such treatment of his machinery, and in all probability he will encounter breakdown at just about the crisis of the dusting period, and quite possibly lose the benefit of all that he has done.

When the dusting machine first arrives it should be carefully inspected as it is assembled, to see that every part is properly adjusted and in good working order. See that there is oil or grease where it should be, and that all moving parts work freely with a minimum of friction.

After the machine is started in operation it is a wise plan to inspect it every day before going into the field, as it is much easier to locate and anticipate trouble in daylight than at night when the machine is in operation. This is a case where a stitch in time may save nine times nine. **Above all things keep the machine oiled and greased.**

After the season's work is over, clean the machine thoroughly before storing it for the winter, and give the finished metal parts and chains a light coat of grease to prevent rusting. Blow the air discharge lines clean, and if the machine uses rubber hose see that there are no kinks in this, as these tend to take a permanent set on standing very long. While doing this cleaning watch for badly worn or defective parts, and either repair the old or order new parts immediately, so that the machine will be in first-class condition to start next season's work.

POISONING DEVICES TO AVOID.

The foregoing pages have outlined the types of poisoning machines found by experience and careful study to yield successful results in the control of the boll weevil. Unfortunately in many cases advantage has been taken of the general interest in the subject of weevil poisoning to induce farmers to buy substitute devices. The claims made for many of these seem plausible, but a study of their operation easily demonstrates that they are unjustified and the devices worthless or worse.

Many have attempted to control the boll weevil with calcium arsenate by the old "pole-and-bag" method, because they were accustomed to using the pole and bag for dusting cotton with Paris green for the control of the leafworm. The results, however, have been sadly disappointing. In the first place this method could not possibly give the thorough dusting of the cotton plant necessary for weevil control, and the sticky nature of calcium arsenate prevents it from passing through any form of bag in any appreciable quantity.

There are now on the market many devices for attachment to plows, walking cultivators, riding cultivators, etc. These consist usually of some form of shaker or rotating screen device for dropping the calcium arsenate on the plants. Needless to say, any attempt to use such devices is a waste of time and money, although there seems considerable possibility that legitimate dusting machinery may be adapted to attachment to cultural implements. Many other devices for use in somewhat the same manner provide for liquid applications of calcium arsenate or some mixture of calcium arsenate and other products. These have proved equally worthless and should be avoided. Still another type is the machine which purports to permit daytime operation by spraying the cotton with water ahead of the dust cloud. Tests have shown that this style not only fails utterly to create suitable conditions for dusting but that in many cases this application of water to the cotton plants during sunshine, followed by the calcium-arsenate dust, causes sufficient scalding to induce a severe fruit shedding.

It is useless to attempt to list all such worthless apparatus. The foregoing devices, however, are typical, and the best rule is to purchase only real dusting machinery which has had the approval of recognized authorities.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1320

THE PRODUCTION OF CUCUMBERS IN GREENHOUSES

GREENHOUSE CUCUMBERS are one of the three most important vegetable crops grown in forcing houses. Large quantities are produced in the forcing ranges around Boston, Mass., Rochester, N. Y., Ashtabula, Cleveland, and Toledo, Ohio, Chicago, Ill., and other points. Lettuce, cucumbers, and tomatoes make up the bulk of the vegetable forcing crop of the United States, according to the 1919 census, being worth about $15,000,000 per annum.

Cucumbers deteriorate rapidly after removal from the plant, but those that are properly grown in greenhouses near the market can be placed in the hands of the consumer in a fresh, crisp condition.

Success depends on the kind of greenhouse used, the availability of cheap fuel and labor, ready access to suitable markets, and close attention to details. Cucumber forcing is a highly specialized form of work, and under favorable conditions the industry is profitable.

There is an increasing demand for cucumbers of the quality that can be grown in greenhouses and delivered to the consumer in a fresh state, and it would seem that there is room for a considerable expansion of the industry.

Washington, D. C. **Issued May, 1923**

THE PRODUCTION OF CUCUMBERS IN GREENHOUSES.

By James H. Beattie, *Horticulturist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

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GREENHOUSE-GROWN CUCUMBERS.

GREENHOUSE-GROWN CUCUMBERS occupy a high place in the estimation of those who have learned to appreciate their superior quality. While the cucumber is not high in food value, it is extremely popular, owing to the fact that it is an appetizer with a sprightly flavor which appeals to most palates. It can be served with various dressings and is much used as an ingredient of salads. The development of the vegetable-forcing industry in this country was largely influenced by the winter demand for cucumbers, lettuce, and tomatoes, and these have always been the most important vegetable forcing crops produced in the various sections of the United States. According to available records, cucumbers are second in importance, with lettuce occupying first place. These crops represent at least 90 per cent of the $15,000,000 annual value of the vegetable forcing crops produced in this country.

LOCATION AND GROWTH OF THE INDUSTRY.

Vegetable forcing in the United States had its pioneer development in the region near Boston, Mass. This was quickly followed by the erection of extensive ranges of forcing houses at Grand Rapids, Mich. Subsequently the industry developed in such centers as Rochester, N. Y.; northern Ohio, including Cleveland, Ashtabula, and Toledo; Chicago, Ill.; and many other places. While the industry is centralized in the places mentioned, it is by no means confined to these areas, as vegetable forcing ranges are to be found in nearly all sections of the country. Wherever the growing of greenhouse vegetables is carried on, cucumbers usually constitute an important part of the product.

Many factors have influenced the growth of the vegetable forcing industry in the sections where it has attained considerable importance. The modern forcing house makes it possible to produce a high-grade product over a wide range of seasons and to put it on the market within a few hours after it is harvested. Cucumbers grown in this manner can be carried to the proper stage of maturity on the vines and put in the hands of the consumer in a perfectly fresh state. Few vegetables lose more in quality by not being served perfectly fresh than does the cucumber. The use of the forcing house makes it possible to mature the crop at seasons when the outdoor-grown product is not available. Moreover, it is possible to grow greenhouse cucumbers so that they can be marketed in competition with much of the outdoor-grown crop produced in the winter-gardening sections of the country, which must bear an exceedingly high transportation and handling cost before it reaches the consumer.

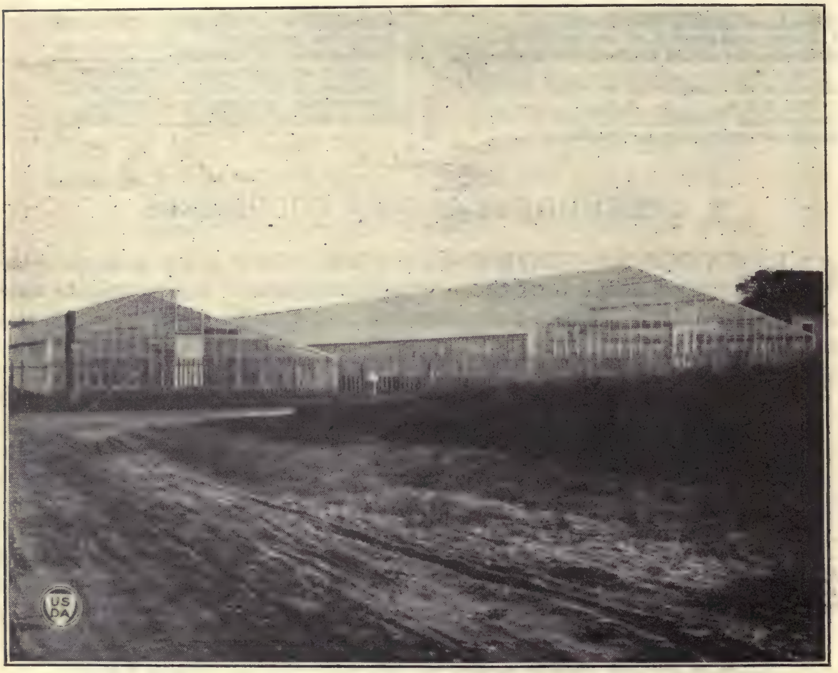

FIG. 1.—A type of greenhouse extensively used near Boston, Mass., and elsewhere for the production of cucumbers and other forcing crops.

Vegetable forcing in the United States is not an old industry, and many of the existing establishments were located without much consideration of the factors affecting the economical production of vegetable crops. In many cases the greenhouses have been built where they now are simply because some one with an interest in such work undertook it in his locality. It should be borne in mind that success in this industry is largely influenced by such factors as suitable equipment, cheap fuel, quick access to markets, a sufficient supply of labor, soil suitable for the crops, and an abundance of water. A supply of stable manure is essential, and if this can not be secured from a near-by city, provision should be made to obtain it from a dairy or stock farm so located that expensive hauling charges can be avoided. The weight of cucumbers is relatively greater than that of the other important forcing vegetables, and in establishing a range where cucumbers are to be the main crop it is important that the location be as near the markets as practicable, on account of transportation costs. It would seem that the grower who produces a high-quality product and puts it on the market in a fresh condition at a price which makes a profit possible has an excellent chance to make a success of the greenhouse-cucumber business.

GREENHOUSES SUITED TO CUCUMBER GROWING.

No important vegetable forcing crop is more sensitive to the conditions under which it is grown than the cucumber, and success in the production of the crop is largely dependent on having houses suited to its requirements. The type of house best suited to cucumber growing is one which is equipped with a heating system with sufficient capacity to maintain a uniform temperature during periods of severe cold, as sudden fluctuations are very injurious to the plants. Drafts are liable to induce powdery mildew, and the house must be of such construction that strong currents of cold air can not reach the plants. A large greenhouse containing a great volume of air is usually less subject to sudden fluctuations in temperature and is easier to ventilate without exposing the plants to drafts than small houses.

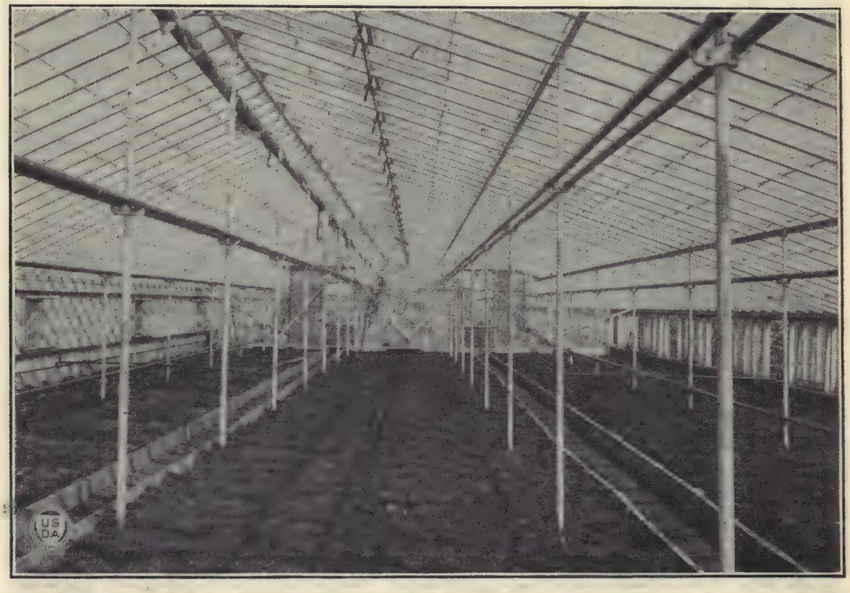

FIG. 2.—Interior of a three-quarter-span house in the Boston area. No benches are ordinarily used, and boards or concrete curbs are made to form the sides of the walks and to keep the soil in place.

In the Boston area three-quarter-span houses from 25 to 36 feet wide and 200 to 600 feet long are largely used for the production of cucumbers and other crops. These houses are usually built with the ridge running east and west and with the long side of the roof to the south. Figure 1 shows the exterior of a typical house of this description. The interior arrangement of such a house is shown in Figure 2. It will be noted that this house is not fitted with raised benches, but that the crops are produced in ground beds with boards along the walks to keep the soil in place. Many of the houses built according to the arrangement shown in Figures 1 and 2 are constructed with wooden posts and wood or cast-iron gutters, with pipe purlins and inside pipe posts, while others, mainly of later construction, are of the semi-iron type with iron posts having special post-top fittings carrying angle-iron eave plates and with pipe or structural steel purlins, purlin braces, and inside posts.

The ridge-and-furrow type of greenhouse, consisting of a number of equal-sized units built side by side with but two outside walls and with the inside gutters carried on rows of pipe posts, making in effect one large house, is largely employed for the production of cucumbers and other vegetable crops. Figure 3 shows the exterior of such a range of houses, and Figure 8 the interior of a similar range. This type of house is used by some of the most successful growers of cucumbers. For the best results it should be built with very high eaves, those with the gutters 8 to 10 feet from the ground being none too high. This plan makes it less difficult to ventilate the house without exposing the crops to drafts from the ventilators.

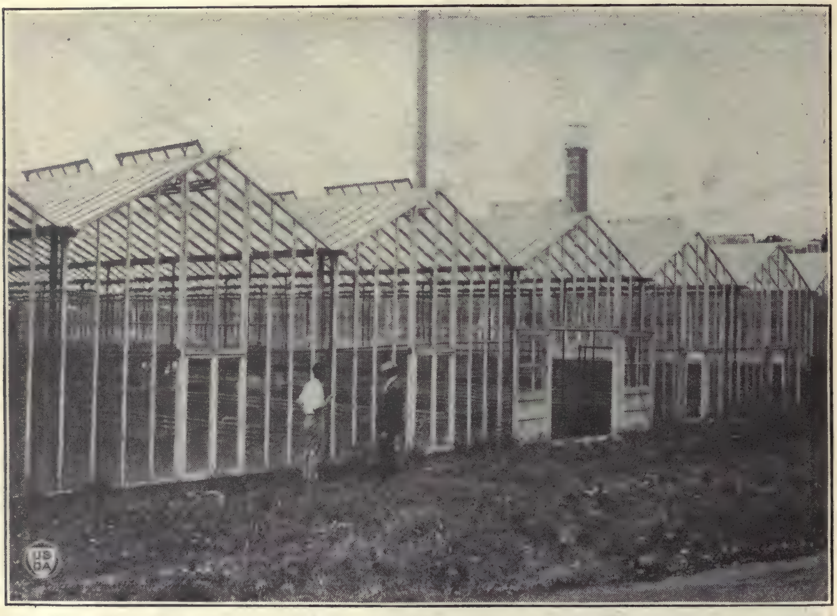

FIG. 3.—Exterior of a range of ridge-and-furrow houses. The high eaves are a desirable feature.

Within recent years the large detached house with a steel frame has become very popular for vegetable forcing, and particularly for the forcing of cucumbers. These houses are built as wide as 85 feet and as long as 600 to 800 feet, inclosing an acre or more of ground. These structures contain a large volume of air, and when fitted with proper heating equipment are not subject to sudden fluctuations in temperature. The ridge of such a house is from 20 to 30 feet from the ground, and there is little danger of air currents from the ventilators striking the plants. Figure 4 shows the interior of such a house planted to cucumbers. Very nearly ideal conditions for the production of cucumbers can be obtained in such houses, as they inclose a large space where not only the temperature but other factors governing the growth of the crop are under the control of the operator.

Cucumbers are successfully produced in many kinds and sizes of forcing structures. The type of house best suited to the needs of the individual grower must be determined by the character of the site, the expenditure which can be made for the structure, and whether the house is to be used mainly for the growing of cucumbers or other crops; but in the light of the experience of successful growers located in many parts of the country the best results can be had through following the suggestions made in the preceding paragraphs.

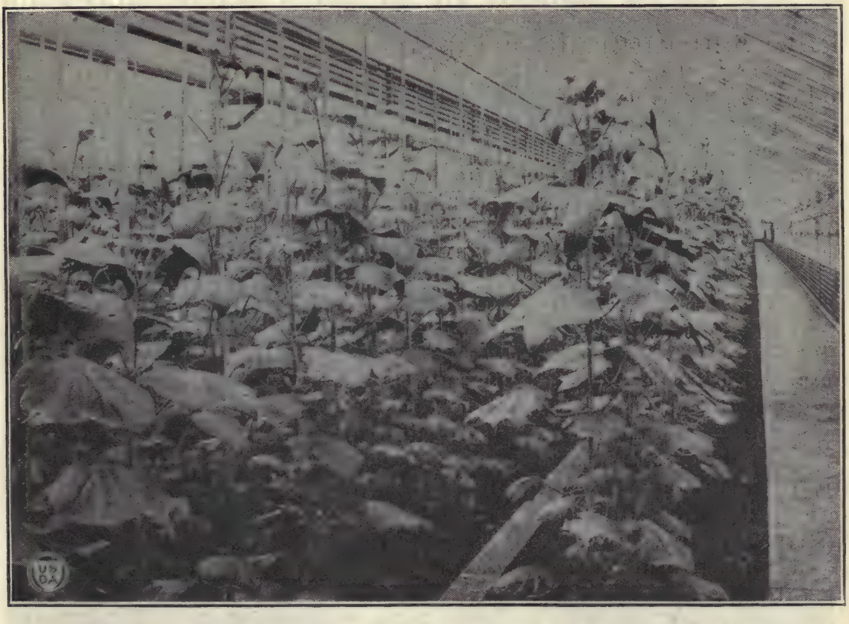

FIG. 4.—Interior of a large steel-frame house planted to cucumbers.

RELATION OF CUCUMBERS TO OTHER FORCING CROPS.

Cucumbers are not a satisfactory greenhouse crop for production during the short days of midwinter, as they demand long daylight hours with plenty of sunshine. They are not very successful as a fall crop, and many growers produce them during the spring, utilizing their houses during other portions of the year for lettuce and tomatoes. Lettuce is about the only crop forced in a large way that does well in greenhouses in midwinter, and practically all forcing ranges grow it during the winter season. Some growers utilize their houses during the autumn months for the production of tomatoes, follow these with lettuce, and then plant the space to the regular spring crop of cucumbers, thus occupying the ground until midsummer, or until it is necessary to prepare for the autumn crops. Other growers plant lettuce early in the autumn and produce two or three crops, then set their houses to cucumbers for the usual spring crop.

COMPANION CROPS.

Cucumber plants require a considerable period to come to bearing size, and short-season crops, such as radishes, lettuce, or spinach, are sometimes planted between the rows of cucumbers in order to produce an income from this space during the early stages of the development of the cucumber crop. Cucumbers demand a high temperature, and the conditions are maintained so that this crop will make its best development. While the companion crops do not, as a rule, thrive best when grown between the rows of cucumbers, it is often possible to secure yields which add materially to the income from the houses thus occupied. These secondary crops are harvested before the cucumber plants reach bearing size. Figure 5 shows a house planted to cucumbers with lettuce as a companion crop.

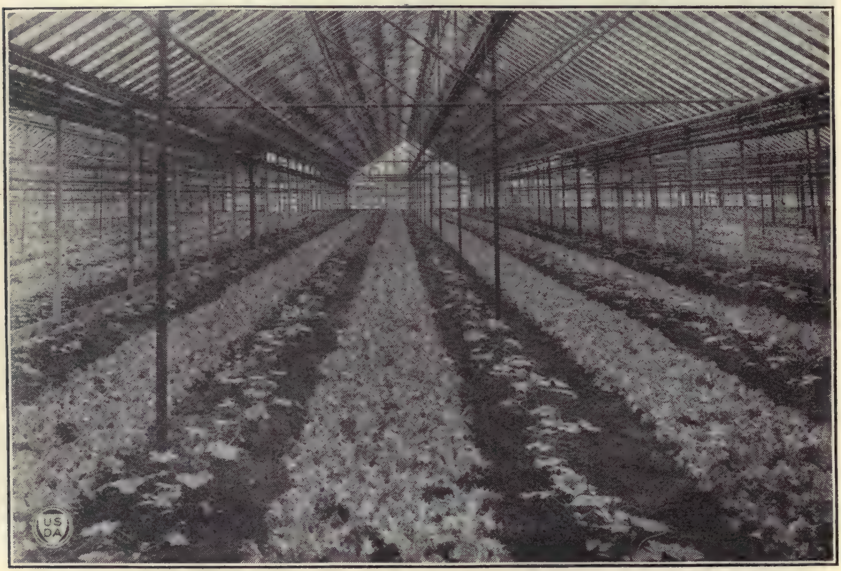

FIG. 5.—Lettuce planted as an intercrop in a cucumber house. The lettuce is removed before the cucumber plants attain any considerable size.

SOILS FOR GREENHOUSE CUCUMBERS.

Rather light-textured loamy soils are considered best for the production of greenhouse cucumbers, but some of the most successful ranges are located on heavier soils. Soils well supplied with organic matter and with plenty of available plant food are necessary to the production of high-grade cucumbers. As long as these essentials are supplied it does not seem to make much difference as to the exact type of soil upon which the crop is produced, but it should be borne in mind that the lighter soils are easier to work and usually have better natural drainage than the heavier types. Good natural drainage is highly desirable. Careful consideration should be given in locating a new greenhouse enterprise for the production of crops to be grown in the natural soil, as is the practice with most of the vegetable crops. If the original soil is naturally good, its physical character can be greatly modified through heavy applications of manure, lime, and fertilizer and the constant working incident to the production of greenhouse crops.

MANAGEMENT OF THE SOIL.

Owing to the high cost of forcing structures and the heavy expenses for fuel and labor to keep the space inclosed in a condition suitable for the crops, it is necessary that the space be fully utilized at all seasons of the year. The greenhouse operator has a more serious problem than that which confronts the outdoor grower, as he must maintain the fertility of the soil and control insects, diseases, and other pests without practicing crop rotation and many other control measures. The nature of these problems has brought about distinct practices for keeping greenhouse soils in a high state of productivity. Glass farming has come to be a highly specialized industry, where the expenses per acre are very high and the returns many times those secured from the most intensive outdoor vegetable growing.

SOIL STERILIZATION.

The sterilization of greenhouse soils as an insurance against diseases which may attack the crop is almost universally practiced by vegetable growers in all sections of the country. It is also an effective control for the nematode which causes the root-knot of cucumbers, tomatoes, and other crops and is also a distinct aid in controlling insects which pass part of their lives in the soil. Successful vegetable growers sterilize the soil once a year, usually in the middle of the summer, between crops.

Sterilization with live steam is looked upon as the most effective method of securing the desired immunity from attack by the various pests. Several methods for sterilizing the soil with steam have been devised, and the one best adapted to the use of the individual grower must be determined by his conditions. One of the oldest methods uses the inverted pan. This apparatus consists of a pan of metal or wood 7 to 10 inches deep, 5 to 7 feet wide, and 10 or 12 feet long. This pan is usually made to correspond to the width of the beds and not too large for the boiler capacity. Figure 6 shows a pan made of sheet metal, this being a desirable type, as it is an easy matter to force the edges of such a pan into the soil so that the steam will not escape. The steam is admitted through a hose attached to a pipe, as shown in the illustration. The pan is of such dimensions that it just reaches across the 12-foot beds in this range of standard-sized houses. The carriage is so constructed that the pan may be raised clear of the soil and rolled to a new location. The concrete walks are so spaced and arranged that they serve as a track for the carriage carrying the pan. The steam hose is of such a length that several settings can be made without disturbing the connection.

Steam is supplied to this 6 by 12 foot pan from a 100-horsepower boiler. A pressure of 100 pounds per square inch is usually carried on the boiler, but this is naturally reduced to a few ounces per square inch in the pan. It would, in fact, be impossible to carry any considerable pressure inside the pan, as it would lift the pan from the ground, allowing the steam to escape. In practice it is usually necessary to place sand bags or other weights on the pan to prevent its rising. The penetration of the steam into the soil is influenced by the character of the soil itself. Tests made with the apparatus shown in Figure 6 with a pressure of 100 pounds at the valve applied for 30 minutes produced a temperature of 210° F. at a depth of 12 inches. The soil in this case was a rather heavy loam, and the pressure used insured high-temperature dry steam. While a steam pan may not be equally efficient under all conditions, it would seem that its use makes it possible to secure temperatures which should be an effective control for most of the soil enemies of greenhouse crops. Soil that is either too dry or too wet does not sterilize to the best advantage. For best results it should contain just about the right proportion of moisture to be in good working condition.

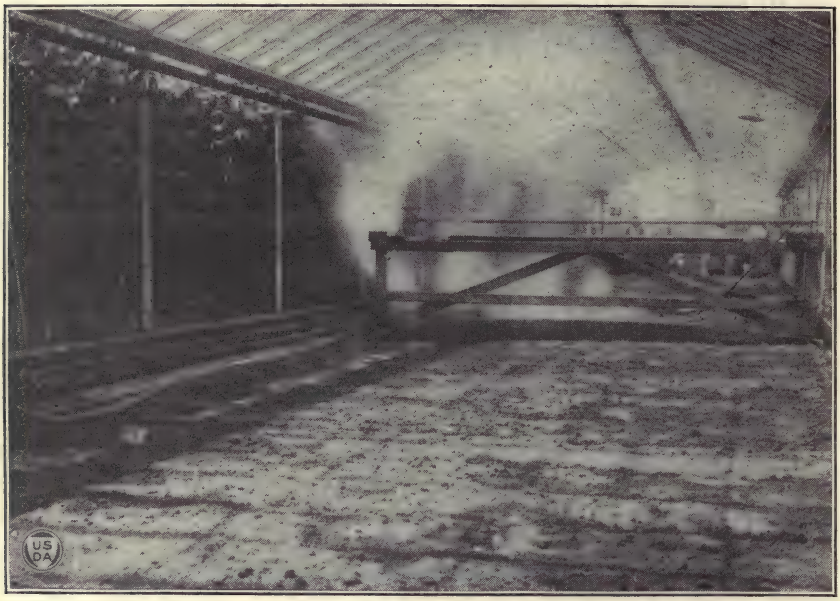

FIG. 6.—Sterilizing greenhouse soil by the steam-pan method. The pan is moved by elevating it with a special hoisting device and rolling the carriage to a new location. The concrete walks serve as a track for the flanged wheels of the carriage. Steam is admitted through the hose and is supplied by a 100-horsepower boiler.

Another method widely employed consists in the use of sets of perforated pipes which are buried in the soil, steam being admitted through a hose connection until the upper 12 or 15 inches of the ground reaches a temperature of 212° F. Pipes 1½ inches in diameter are usually employed in sterilizing. These are attached to 2-inch headers, the pipes being spaced about 1 foot apart and having ⅛-inch holes drilled at intervals of a foot along the bottom of the pipe. The set of pipes may be as long as desirable, but their number and length are determined by the size and shape of the beds and the available boiler capacity. One concern in northern Ohio uses two sets, each made up of ten 1½-inch pipes 85 feet long and spaced 1 foot apart. When both of these are in use at the same time it requires 450 horsepower at the boiler to supply sufficient steam. It is possible for those having small boilers to fit up sterilizing coils of a size suited to their capacity. Figure 7 shows a sterilizer made up of four lines of 1¼-inch pipe 20 feet long, spaced 1 foot apart, and fed with steam from a 20-horsepower boiler. A set of these pipes is buried near the right side of the greenhouse shown in the illustration, the steam entering through the hose connection. A workman is covering a second set, so that the connection can be shifted to this and the work carried on continuously. This method is very effective, but it is laborious and costly. Considerable hot, disagreeable work is involved in burying and changing the pipes during midsummer weather, when the sterilization is usually carried on. The quantity of fuel required for sterilizing by the perforated-pipe method is not greatly different from that needed for sterilizing by the pan method, but the labor is no doubt greater.

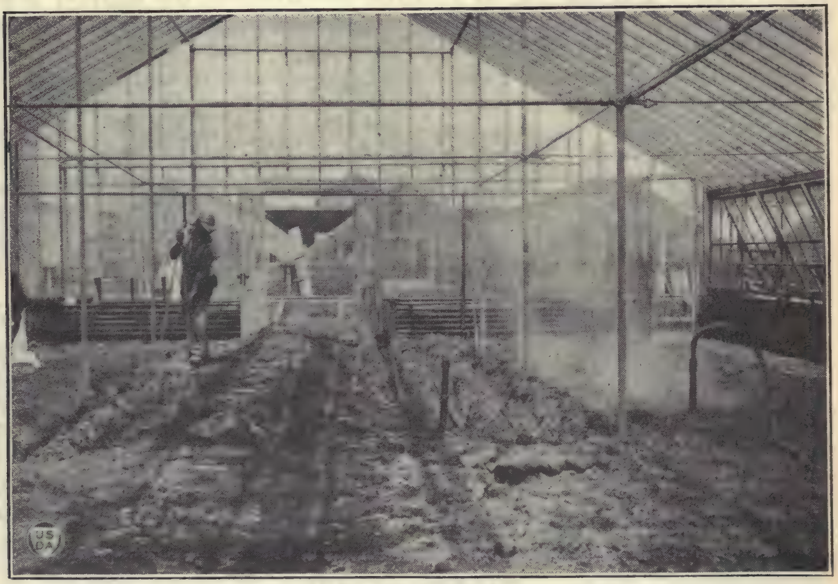
Fig. 7.—Sterilizing greenhouse soil by the perforated-pipe method. The sterilizer is made up of lines of pipe connected by headers, the size and number of the pipes depending on the size of the beds and the boiler capacity available. The workman is covering one set of pipes while the other is in use.

Still another method, known as the steam harrow or rake system, is used to a considerable extent. A framework of pipe of a size suited to the beds to be treated is fitted with pipe teeth similar to the teeth of a coarse rake. These pipes are of small diameter, usually ⅛-inch and about 6 inches long, with the bottom end closed by being flattened and with ⅛-inch holes drilled through them near the lower end. The teeth are spaced about 6 inches apart in each direction. The apparatus is attached to the steam supply by a hose, and the steam forces its way through the small holes into the soil. In using the sterilizer the teeth are forced into the soil, and the device is covered with a canvas to retain the heat. When the operation is completed in one place the rake is lifted by the workmen and moved forward to the next location. Two or more of these rakes are usually used by the same men, so that the work can go on continuously. This device does very effective work, and the labor involved is not great.

Permanent lines of 4 or 5 inch draintiles are sometimes installed about 1 foot deep and from 18 inches to 2 feet apart in the greenhouse and live steam turned into these until the soil reaches a temperature of 210° F. or more. While the lines of tile can be used for subirrigation purposes as well as for sterilization, the method is not very satisfactory, and it is being abandoned by most of the growers who have installed the lines of tile in their houses, as it seems to be impossible to secure an even distribution of the steam, resulting in incomplete sterilization.

Sterilization is sometimes accomplished by flooding the soil with boiling water or by forcing boiling water into the soil through a pipe fed by a hose connected to the boiler. This method is often practiced in plants where steam is not available, and it gives very good results. One objection to its use is that it leaves the soil in a puddled condition, and considerable time must elapse before it can be prepared for the crops.

A solution of formaldehyde, 1 pound of the commercial solution to 30 gallons of water, used at the rate of a gallon of the solution to each square foot of bed surface, is quite extensively employed for the control of diseases affecting greenhouse crops. The method is expensive and hardly practical for large areas of greenhouse soil, but highly desirable and economical for plant beds, etc. After treatment the soil should be allowed to lie for several days before seeds or plants are placed in it. Here again, as in steam sterilization, it is important that the moisture content of the soil be normal.

STABLE MANURE.

Stable manure is essential to the best results with greenhouse cucumbers. In the past, little difficulty has been experienced in securing ample supplies from the large cities, but this supply has dwindled until it is now impossible to obtain an abundance of good manure at a moderate price. Much of the manure now coming from the large cities is of poor quality. Special precautions should be taken to avoid the use of manure swept from the streets, as this usually contains considerable oil and particles of paving material. Manure from oiled roads also should be avoided, as the oil contained in such material is usually present in sufficient quantity to be distinctly injurious to the plants. It is also advisable to avoid the use of manure mixed with shavings or sawdust, as it is liable to be injurious. Many growers have adopted the expedient of securing their supplies from some near-by dairy or stock farm, often operated as an adjunct to the greenhouse enterprise for the purpose of supplying the manure essential to success with forcing crops.

For growing cucumbers it is desirable that the manure be applied at the rate of 30 to 40 tons to the acre, or about a 2-horse load to every 1,000 or 1,500 square feet of ground. The application of such dressings of manure, made just after the soil is sterilized and before it is plowed, should be looked upon as a necessary practice for maintaining the soil in a high state of productivity. The actual plant-food requirements of the crop should be largely provided for through top-dressings of manure and fertilizers applied from time to time as the plants develop. The application of large quantities of manure involves considerable labor, but this can be reduced by the use of suitable equipment. Large greenhouses should be fitted with doors of such size that the manure can be hauled directly into the house by team. Figure 8 shows the interior of such a house in which the manure is being placed in piles and spread preparatory to plowing the ground. In some cases manure spreaders are employed for hauling and spreading the manure in the houses.

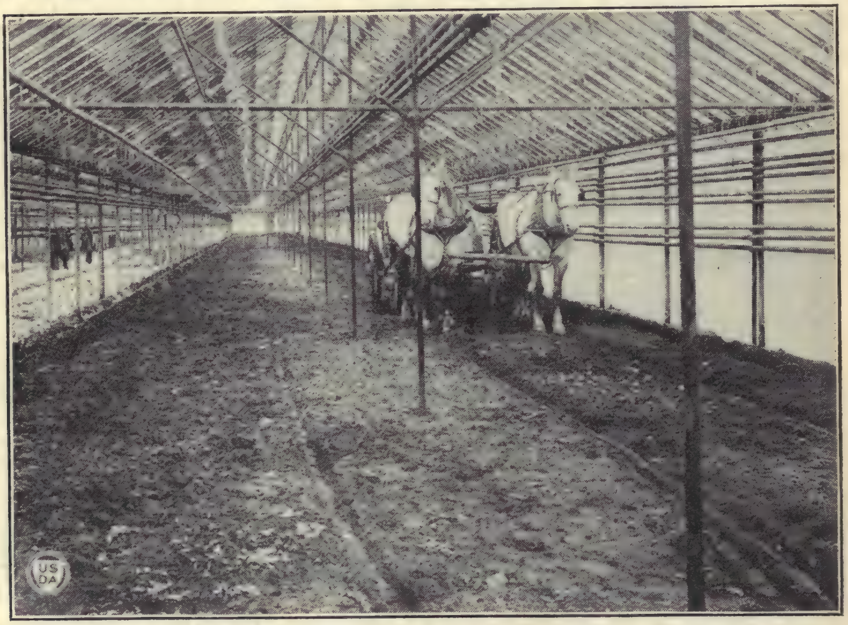

FIG. 8.—Hauling manure into the greenhouse. In this case the manure is spread by hand, but manure spreaders are sometimes employed.

PREPARATION OF THE SOIL.

In modern vegetable forcing houses the soil is plowed and prepared largely by a team or by a tractor, but in houses whose construction is such that this is impossible or difficult the work is usually done by hand. Figure 9 shows the plowing in process, a single horse being used in this case, but a moderate-sized tractor capable of turning within a short radius could be employed to good advantage. Most growers believe that the soil should be turned to a depth of at least 10 inches. The method usually employed in incorporating the manure with the soil is to have men place the manure in the furrow after each round of the plow, thus insuring its being covered thoroughly. Figure 9 shows piles of manure ready to be placed in the furrows as the plowing proceeds.

The preparation of the soil after the plowing is completed is usually accomplished through the use of a disk harrow, a drag, or a similar tool. It is the aim of the best growers to provide a perfectly prepared seed bed 6 or 8 inches deep, and the equipment used to accomplish this result is determined by the nature of each case.

PLANT FOOD FOR THE CROP

A rapid uninterrupted growth is necessary if a satisfactory crop of high-grade cucumbers is to be obtained. This makes it necessary that the soil be well supplied with plant food before the crop is set, so that the young plants will have an immediate supply of all the elements essential to their proper development. In the past many growers have made it a practice to depend almost entirely on manure for the plant food for the crop, but as this does not always supply the quantities of the essential elements needed for heavy yields there is a growing tendency to depend on commercial fertilizers for most of the food supply, with good manure free from shavings, sawdust, or other injurious materials supplying the organic matter and part of the plant food. Applications of 1,000 to 2,000 pounds per acre may be made of a fertilizer containing 4 to 5 per cent nitrogen, about half of which is in the form of nitrate of soda or sulphate of ammonia and half in the form of dried blood or tankage, 7 to 9 per cent of acid phosphate, and 4 to 5 per cent of potash in the form of muriate. Some growers modify this by using

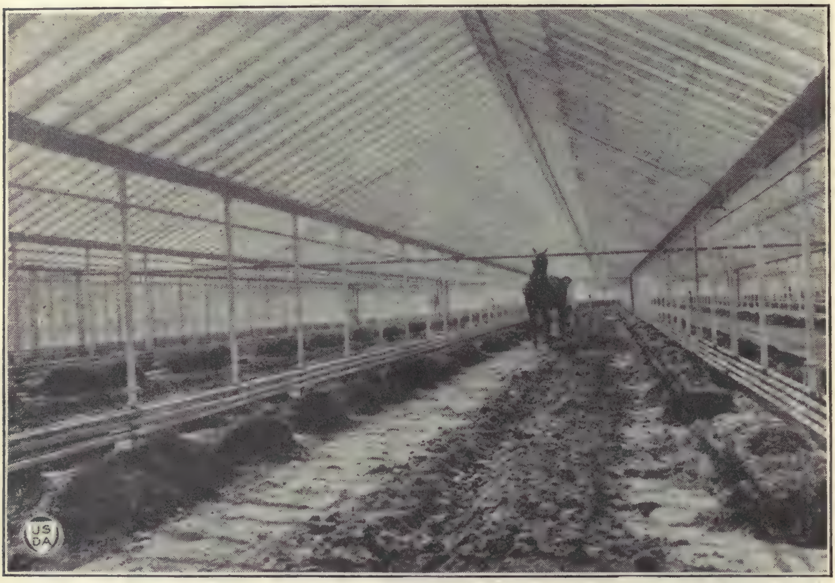

FIG. 9.—Plowing in the greenhouse with a 1-horse plow. The manure is being applied and turned under as the plowing progresses. Sometimes 2-horse tools are used, and in other cases small tractors are employed.

a mixture containing not over 4 per cent of potash and apply hardwood ashes containing from 2 to 4 per cent of potash at the rate of 1,000 to 1,500 pounds per acre. These materials are usually sown broadcast with a fertilizer distributor or by hand. All these materials are supplied during the final stages of the preparation of the soil and are supplemented by special applications while the crop is growing.

LIME.

Owing to the intensive cropping systems followed in the greenhouse, the soil is liable to become acid, and lime must be used to correct this acidity. The need for lime may be determined by testing with litmus paper or by a lime determination in a laboratory, or, what is usually the best practice, the greenhouse man may make experimental applications from time to time, using the information thus secured as a basis for the treatment of the remainder of the range. The cost of lime is low, and the grower should not take the chance of poor crops due to lack of lime in his soil. The form in which the lime should be applied must be determined by conditions. If quick results are desired the use of ground stone lime or hydrated lime may be advisable, but where a slower acting form is desirable ground limestone is satisfactory. Applications of from 1,000 to 2,000 pounds per acre will usually be found sufficient. It is better practice to make rather frequent and small applications than to give heavy treatments at infrequent intervals. The use of lime more than once each year is seldom necessary.

VARIETIES AND SEED.

Two distinct classes of cucumbers are used for forcing in the United States. The English forcing type is represented by such varieties as the Telegraph and the Duke of Edinburgh. Cucumbers of this class are extensively grown in forcing houses in the eastern portion of the country and to a slight extent in the Middle West and the West. The major portion of the cucumber crop produced in this country is of the American field type, of which special forcing strains have been developed. In some cases crosses have been made between the English forcing varieties and the American sorts. The Abundance and Davis Perfect are two of the best-known crosses, and these are extensively grown. A sort known to growers as the Long Green is probably a selection of the Telegraph and is quite largely grown by vegetable forcing interests in Ohio and Michigan. Most of the American forcing strains belong to the White Spine group. Some of the best-known varieties of this group are the Improved Arlington White Spine, the Extra Long White Spine, and the Evergreen White Spine. Many growers have developed strains of their own and save their own seed from year to year, and some of these have been named as varieties. Such a selection, known as the Irondequoit, is grown in the Rochester, N. Y., area.

Sometimes the seed crop is grown out of doors during the summer months, and in other cases it is saved from the greenhouse crop. In either case selected plants are set aside for seed purposes and the entire supply secured from those plants having the desired characteristics. The general character of the plant, including its vigor, productiveness, resistance to disease, and longevity, is taken into account in making the selection. The success of the greenhouse crop depends to a large degree on the seed; hence, extreme care should be exercised to secure a satisfactory supply.

MANAGEMENT OF THE CROP.

STARTING THE PLANTS.

Strong healthy plants are essential to a satisfactory crop of greenhouse cucumbers. It is desirable that the crop occupy space in the houses for as short a time as possible, so as to make room for the greatest number of crops during the year. For this and other reasons the plants are usually started in a separate house where they can be given special care, and when several weeks old they are placed in the house where the crop is to be produced. Figure 10 shows the interior of a house used for the production of plants for a large range. Part of this house is fitted with benches to facilitate the handling of the plants. The benches, flats, tools, and all the equipment used in the production of the plants should be thoroughly disinfected each time a crop is produced. This may be accomplished by spraying or washing the equipment with a solution made by adding 1 pound of formaldehyde to 30 gallons of water or by dissolving 6 ounces of corrosive sublimate in 50 gallons of water. It is an excellent plan to keep in one of the plant houses all the tools needed for the production of the plants and to allow no transfer of such equipment without sterilization from other parts of the range

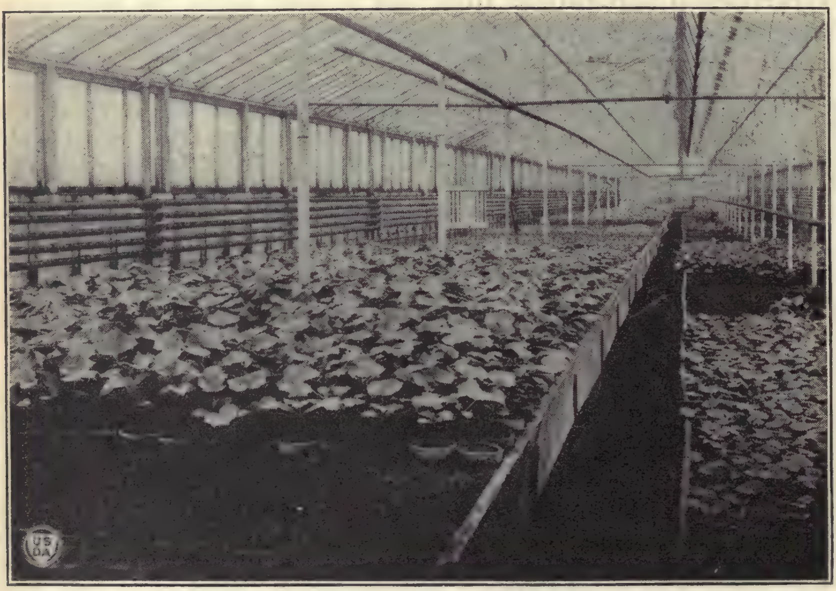

FIG. 10.—Cucumber plants in 4-inch pots. The seed for these plants was sown in a bed and the plants transferred when about two weeks old. Often the seed is placed directly in the pots or other containers used.

to the plant houses, as such a practice might introduce diseases from the other houses to the section where the plants are being grown. It is also unwise for the workmen handling the crop in other sections of the range to have access to the plant house, as diseases may be carried on their hands and clothing to the young plants. When the same person is required to look after the work in various portions of the range, it is well for him to sterilize his hands in a solution of mercuric chlorid of the same strength used for the benches and tools; also to change his outer clothing before entering and handling the young plants. Special precautions are necessary, as usually some disease is present in the bearing crop, and if the young plants become infected their chances for developing into strong high-producing plants are materially lessened.

Soil used for the production of cucumber plants must be of good physical character and well supplied with available plant food. A soil prepared by composting 2 parts of old bluegrass, redtop, or other suitable sod and 1 part of cow manure is usually satisfactory, although many growers make a practice of adding 2 or 3 pounds of bone meal or a high-grade fertilizer to each ton of the soil. A mixture containing 4 to 5 per cent of nitrogen in the form of dried blood and nitrate of soda or sulphate of ammonia in equal proportions, 7 to 8 per cent of phosphoric acid, and 3 to 4 per cent of potash is suitable for this use. Soil needed for the production of cucumber plants for a spring crop should be composted during the previous autumn, turned once or twice during the late fall before severe freezing weather occurs, and brought into the plant house during the early winter, so that it will be available when needed for starting the plants. The soil should not be allowed to dry out while being prepared for the production of the plants, and the aim should be to keep it in a satisfactory condition for plant growth. When fertilizer is used it is as a rule mixed with the soil at the last turning before the crop is to be started. In the final working of the soil it is a good practice to use a screen of about one-half-inch mesh, similar to a coarse sand screen, so that all lumps and foreign material can be broken up or removed. The screen illustrated in Figure 11 is well adapted to the work. Time and care devoted to the preparation of the soil for the production of cucumber plants will pay good returns.

Sterilization of the soil used for the production of cucumber plants is extremely desirable, and the process should be carried on at least two weeks before the seed is to be sown. Sterilizing may be accomplished by spreading the soil on the floor of the greenhouse or on one of the benches and using the steam pan already described and illustrated in Figure 6, or the soil may be placed in flats which are stacked on a truck and run into a cabinet, as shown in Figure 12. This cabinet is of concrete with a wooden door. One can be constructed of lumber or of metal and need not be expensive. Steam is admitted through the top by means of a pipe leading to the boiler and is distributed by a perforated pipe running the length of the cabinet. In practice the steam is admitted until the soil reaches a temperature of about 212° F., this usually requiring about half an hour. In some cases the soil is sterilized in bulk in a cabinet, but this means additional handling. Sterilization in an oven or by fire is not usually advisable, as it injures the productive qualities of the soil.

Several methods are employed for the production of greenhouse cucumber plants. (1) The seed is sown in beds and covered with one-half inch of sandy loam, leaf mold, or finely divided peat. As soon as the seedlings are up, which will be in about a week, they are transplanted to 3 or 4 inch pots or to veneer plant bands which are set in flats or directly on the benches of the plant house, as shown in Figure 10. Some growers transplant the seedlings to 2-inch pots and make a second transplanting to larger pots, but as this entails considerable extra work and the results do not seem to be markedly superior to those secured with one transplanting, the practice of making two transplantings is not generally followed. (2) The seed is placed in the pots or the plant bands employed and covered with one-half inch of leaf mold, peat, or some similar material which will not pack. Several seeds are usually placed in each container and the resulting plants, thinned to two and finally to one, are grown on the benches in the plant house. This method may be modified by using a piece of inverted sod, a paper band, or some other device for supplying the plant with a mass of soil in which its roots can develop and which can be transferred to the location where the plant is to grow without disturbance of this root system.

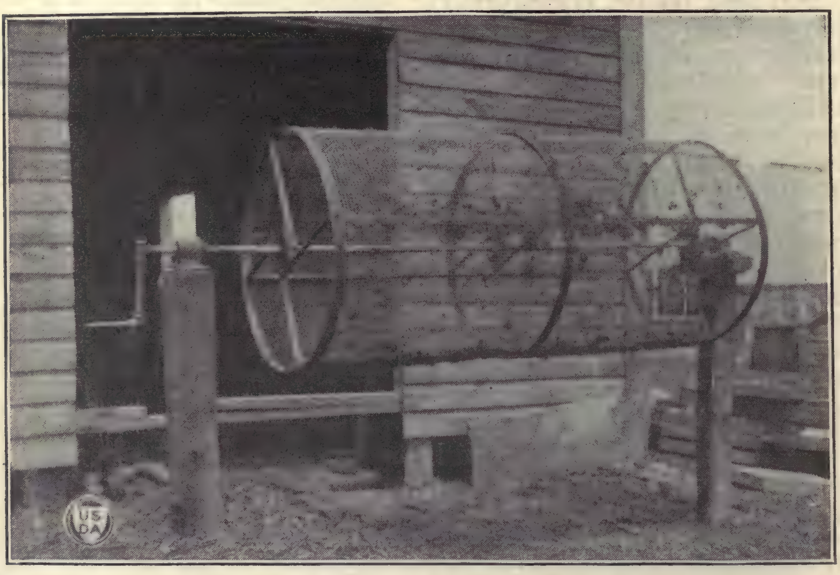

FIG. 11.—A type of screen well adapted to the preparation of the well-fined potting soil needed for the production of cucumber plants. Such a screen can be operated by power if desired.

Extreme care must be taken in handling the plants, as stunted and diseased seedlings will not give a satisfactory crop. It is a far better practice to grow the plants under the most favorable conditions in the shortest practicable number of days consistent with sturdiness and vigor than it is to sow the seed too early in the season and depend on bringing the plants to the correct size by planting time. With the proper conditions, it is possible to secure strong, healthy plants with several leaves and beginning to vine in from five to six weeks from the seed.

The temperature and general management of the cucumber house are very important factors in the production of good plants. The young plants are particularly sensitive to low temperature. Night temperatures of 65° to 70° and day temperatures of 75° to 85° F. will usually give good results. The house must be properly ventilated, but this should be accomplished without sudden changes in temperature, and it is especially necessary that drafts be avoided. While the plants need considerable water, it is an easy matter to use too much, with resultant trouble from "damping-off." Insects should be controlled by the same measures used for the main crop, as explained elsewhere in this bulletin.

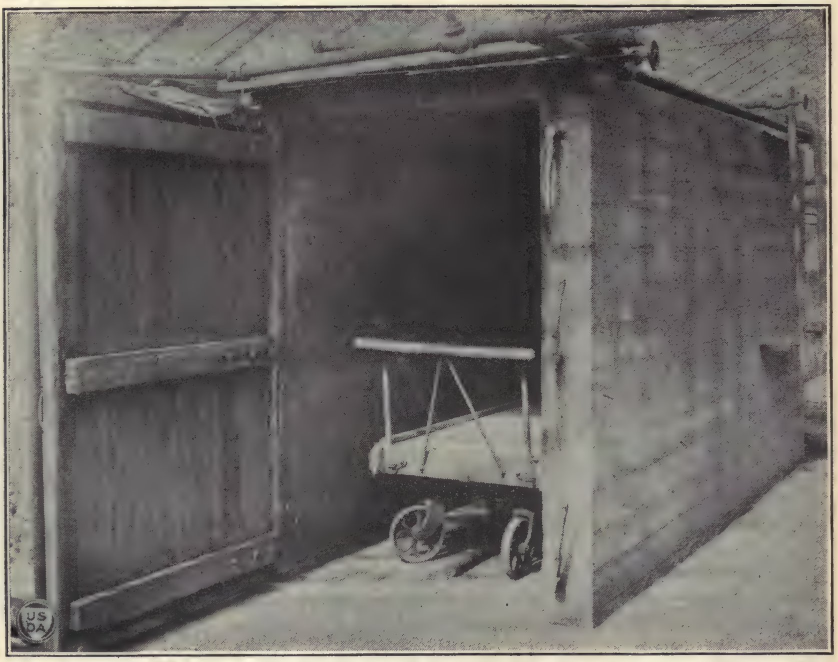

FIG. 12.—A concrete cabinet for the sterilization of soil for the production of cucumber plants. The soil is placed in the containers in which the plants are to be grown and these put in the cabinet, the door closed, and the steam admitted through the pipe in the top of the cabinet until the soil is heated to 212° F. From a half hour to an hour is usually required.

SETTING THE PLANTS.

The most satisfactory planting distance will depend on the training system adopted. Three main systems of training cucumbers are in use, but several modifications of these are described in this bulletin. The planting distance must be made to accord with the system followed. When the A-trellis system is to be used, the plants are set in rows from 7 to 9 feet apart with the plants from 10 to 18 inches apart in the row. The distance between the rows is usually proportioned to the width of the houses. With the "arbor" system the plants are set in rows 6 to 7 feet apart, with the plants from 2½ to 3 feet apart in the rows. The width of the rows may be varied in this case also to suit the dimensions of the house. When using the other important system the plants are trained to stakes or strings attached to wires stretched across the house, and each plant is kept free and distinct from its neighbors. The distance between the rows varies from 3 to 4½ feet, with the plants from 1 to 2 feet apart in the rows. The closer the rows are, the farther apart are the plants in the rows.

Cucumber plants should not be placed in the houses until the ground has been thoroughly prepared. It is very important to have the soil in a satisfactory condition to promote growth as far as moisture and temperature are concerned. The rows must be straight, and this is usually accomplished with the aid of garden lines, or the ground may be marked out with a horse-drawn tool. If the plants have been grown in pots, each may be removed with the ball of soil intact by turning the pot upside down and tapping the edge of it on some projection, such as the handle of a wheelbarrow, catching the plant in the other hand as it loosens from the pot. If the plants are well watered before planting is begun, it will be a distinct help in keeping the soil surrounding the roots from crumbling. If wooden or paper bands are employed for growing the plants, these may be slit down the side or one corner and removed before setting the plants in the hole previously prepared. The soil should be well firmed around the plant after it is placed in the hole, and it is advisable to follow the planting very closely with a moderate application of water around the roots of the plants. A little manure used as a mulch about the freshly set plants is a decided advantage.

TRAINING.

Figure 13 illustrates the A-trellis method of training the plants. The trellis is usually constructed of 2 by 4 inch scantlings mitered together at the top and set in the ground at the bottom, usually with the apex of the trellis over a path. These timbers are from 7 to 10 feet long, depending on the width of the house and the distance between the rows, and are placed sufficiently close to prevent the sagging of the wires. Horizontal wires are stretched every few inches and fastened to the scantlings by staples. As the vines grow they are trimmed to a single stem and tied to the wires, one after another, as the growth of the vine progresses. The lateral shoots are nipped off just beyond the first female flower, and when the vine reaches the top of the trellis the terminal bud is nipped off. It is seldom practicable to keep the vines perfectly pruned, but unless the work is looked after with extreme care an excessive vine growth will soon result.

When trained and pruned according to the "arbor" system every plant is trimmed to a single stem and trained to a string or wire attached to an anchor or stake set beside each. These supports are attached to a horizontal trellis 6 or 7 feet from the soil and fastened to the frame of the greenhouse. This trellis is usually made of wires placed at sufficiently close intervals to form enough support to sustain the plants as they spread over its surface. Each plant is allowed to set several cucumbers while it is reaching the trellis, but after the vines begin to spread over it they shade the underneath portion so much that further development of fruit or foliage is not possible. As soon as the plants reach the trellis the terminals are nipped off, with the result that several lateral branches arise near the place where the terminal was cut. These spread over the supports, and the cucumbers are borne hanging through the trellis. Some pruning is necessary from time to time to prevent too rank a growth of foliage. Figure 14 shows the interior of a house where this system of training is in use.

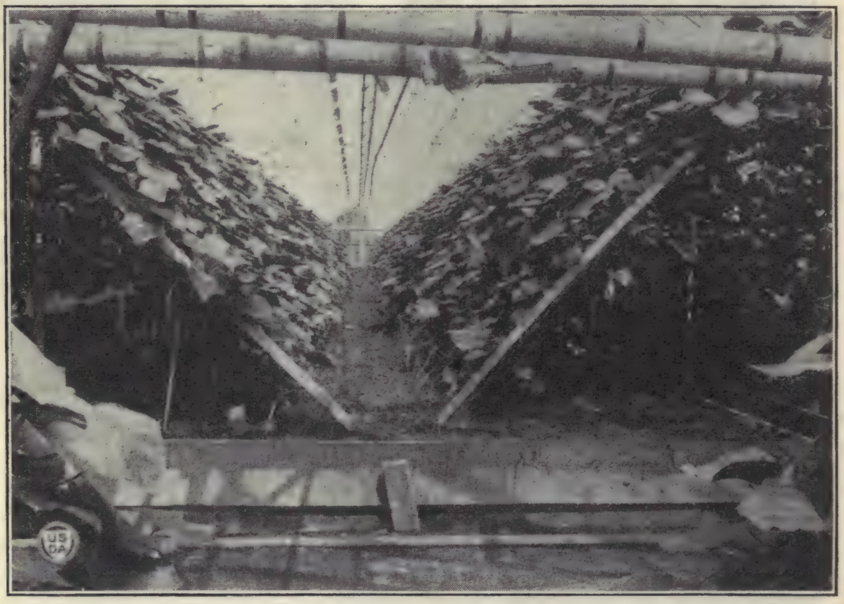

FIG. 13.—Form of trellis largely employed for training cucumbers. The framework is of 2 by 4 inch or 3 by 4 inch scantling, and wires are stretched horizontally every few inches. The cucumber plants are trimmed to a single stem, trained, and tied to these wires.

Figure 4, page 7, shows a house where the upright system of training is employed. Each plant is trimmed to a single stem and either tied to a slender lath attached to overhead wires carried by the frame of the house or to a heavy string attached to a similar support. Many growers prefer the string supports, as the vines can be twined around the strings as the growth progresses, thus avoiding a great deal of the tying necessary when lath supports are employed. The lateral shoots are cut off just beyond the first female flower, and the plants are often carried to a height of 8 feet from the ground before the terminal shoot is nipped. Considerable training is necessary to keep the plants within bounds. This system allows the sun to have free access to the plants, and under such conditions there is less liability of diseases developing. Modifications of these systems can readily be made to suit the conditions of each grower.

TEMPERATURE AND VENTILATION.

Most growers believe that cucumbers do best with a night temperature of from 65° to 70° and a day temperature of 75° to 85° F. While there is a difference of opinion as to the exact temperature needed by the crop, there is none as to the necessity for a uniform temperature. Marked fluctuations in temperature are injurious to the crop, and sudden changes are distinctly harmful. The houses must be equipped with heating apparatus that will maintain a steady, uniform temperature; moreover, the desired temperature must be maintained while suitable ventilation is given. A large part of the material used by the plant in its growth comes from the air in the form of carbon dioxid. The atmosphere normally contains but a small percentage of this constituent, and it is necessary that the plants have fresh air in order to thrive. Ventilation must be given without subjecting the plants to drafts, as they will induce powdery mildew and other troubles. By opening the ventilators on the side of the house away from the direction of the wind it is usually possible to secure sufficient ventilation without a draft. Some air enters through doors, crevices, etc., and a large portion of the necessary fresh air may reach the plants in this manner. Successful cucumber growers pay close attention to the ventilation of the houses, opening and closing the ventilators as often as necessity arises. A sudden overcasting of the sky or a thunderstorm may necessitate closing the

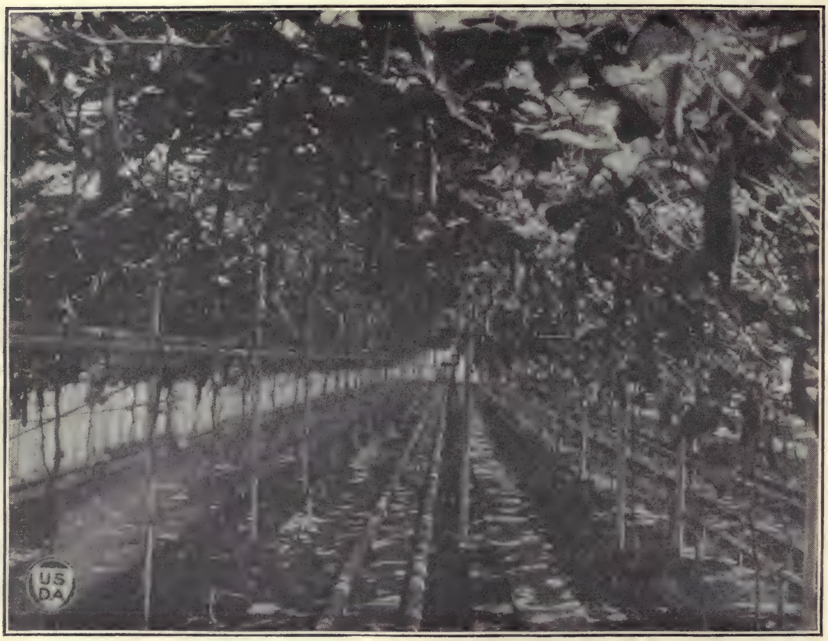

FIG. 14.—The "arbor" system of training cucumber plants, in which the vines are allowed to spread over a trellis some 7 feet above the ground. Strings tied to anchors in the soil and to the overhead trellis support the vines until they reach the trellis.

ventilators quickly, and the clearing away of the clouds may require the opening of them just as quickly. Cucumber houses must have constant attention.

CULTIVATING AND FEEDING THE CROP.

When the soil has been given the proper preparation before the plants are set in the houses, cultivation becomes a simple matter and is limited to the maintenance of a soil mulch and the control of weeds. While it is necessary to cultivate the crop during its early stages, many growers believe that there should be little stirring of the soil after picking begins. The cucumber is a very shallow rooted plant, and it is an easy matter to injure it through deep cultivation. Many growers make a practice of applying a mulch of fine strawy horse manure to keep the soil from packing and to control weeds, thus avoiding the necessity of stirring it. This mulch as a rule is not applied until after the plants begin bearing. Such a covering adds considerable plant food to the soil and is a distinct help in controlling moisture and in securing good yields.

Applications of stable manure and fertilizers, as discussed in considering the preparation of the soil, will usually be sufficient to provide for the needs of the crop during the early stages of its yielding period. The plants are exceedingly heavy feeders, and if profitable yields of cucumbers are to be expected the grower must fertilize them liberally. While good manure mulch applied about the time the plants come into bearing is a distinct help, this needs to be supplemented by the addition of such organic fertilizers as dried blood, pulverized sheep or cattle manure, or tankage. Chemical fertilizers, such as nitrate of soda, sulphate of ammonia, acid phosphate, or muriate of potash, may be employed, but these can be used in limited quantities only. Applications of 5 to 10 pounds of dried blood or tankage may be made to each 1,000 square feet of ground surface. Nitrate of soda or sulphate of ammonia should not, as a rule, be used at a rate greater than 200 pounds per acre at a single application. The potash salts may be used at a somewhat heavier rate, while acid phosphate can be safely employed at a rate as high as 600 to 800 pounds per acre. The individual grower must study his conditions and learn the best fertilizer practice for him to follow. Where it is possible to secure plenty of manure, it is unnecessary to use large quantities of commercial fertilizers. If it is possible to secure such fertilizing materials as wood ashes, they may supply the cheapest form of potash. Irrespective of its source, plant food must be supplied in sufficient quantities to keep the plants in a vigorously growing condition.

POLLINATION.

Both male and female flowers are borne on the same cucumber plant. The female flowers may be readily distinguished from the male by the presence of the small cucumber between the flower and the stem. Figure 15 shows both male and female flowers on the same plant. The male flowers usually appear first, and this sometimes creates the impression that cucumbers will not be formed. This habit of the plant seems to be a provision of nature to insure a supply of pollen when the female flowers are ready. Pollination must be performed by some outside agency, and in greenhouse practice bees are usually employed for the purpose. The hives are kept either on the outside of the houses, usually with a pane or two of glass removed, and the hive so placed that the bees enter the house through these openings, or the hives may be inside the houses. The number of swarms required to properly pollinate the cucumbers depends on the strength of the swarms and the size of the house. One strong swarm is usually sufficient for a medium-sized house, while the very large houses now extensively employed for the forcing of

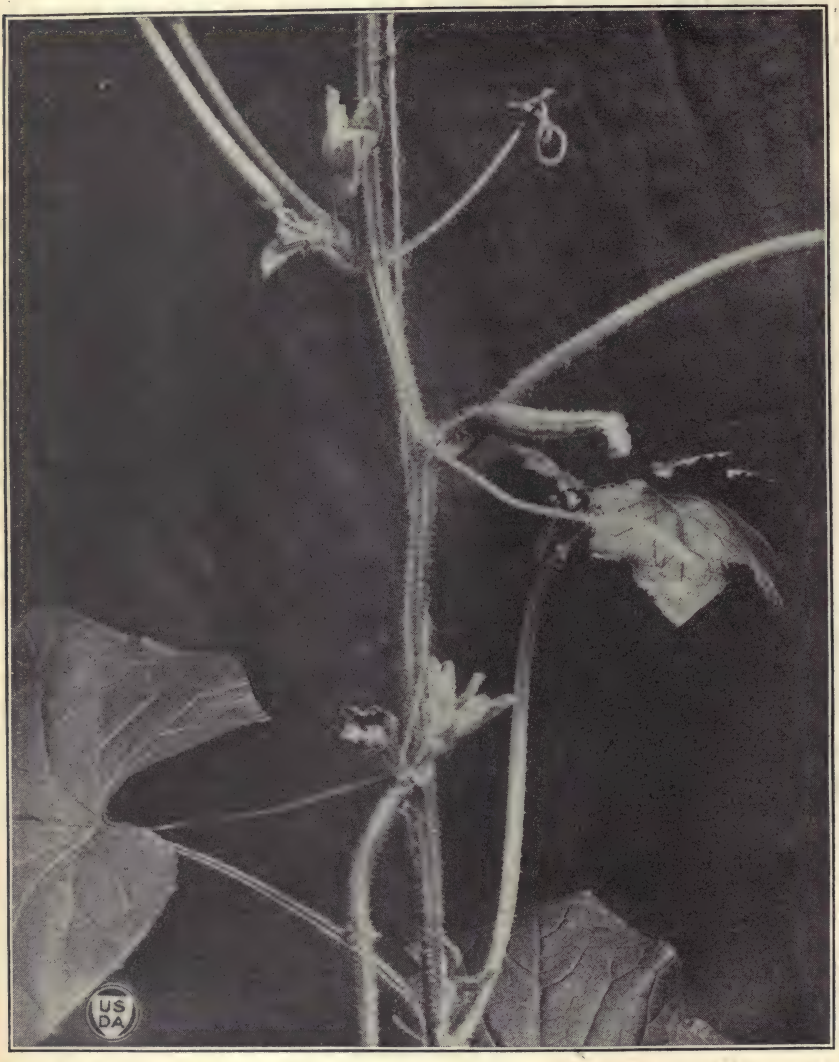

FIG. 15.—The male and female flowers of the cucumber. The flower of the female blossom is withering, and the small cucumber shows its location.

cucumbers may require six to eight swarms. The bees used for this work must be carefully looked after, and most operators make a practice of feeding them regularly, as they do not seem to be able to secure sufficient food from the cucumbers. The hives, as a rule, are used for only a few weeks at a time and then returned to the apiary for a rest. Some of the larger greenhouse concerns maintain apiaries to supply them with bees for pollinating the cucumber blossoms. The work is sometimes done by hand, using a camel's-hair brush for transferring the pollen, but this method is laborious and is not to be recommended except for very small houses.

WATERING.

Cucumbers thrive best when liberally supplied with moisture, but the application of water may very easily be carried to the point where it becomes injurious. Many growers believe that it is better to give the soil rather heavy and less frequent applications. Many cucumber houses, especially those built during recent years, are equipped with overhead irrigation systems. Some growers believe that these systems interfere with the work of the bees, but if the watering is done in the early morning while the bees are not at work, this objection does not apply. The use of such a system saves a great deal of hand work, distributes the water evenly, and the spray is a help in controlling the red spider. Should anthracnose, downy mildew, or angular leaf-spot appear, overhead irrigation should be discontinued or used very sparingly.

ENEMIES OF GREENHOUSE CUCUMBERS.

RED SPIDER.

One of the serious pests affecting greenhouse cucumbers is the red spider,[1] which works on the foliage and unless controlled is almost sure to ruin the crop. Numerous control measures are used. Probably the most satisfactory method is to sterilize the soil with steam, as previously described, the sterilization being carried on during the summer months while the houses are unoccupied by crops. The absolute control of weeds both in and around the greenhouse in summer is a distinct help in controlling the red spider. Fumigation is ineffective, but spraying with soap solutions, using a pound of fishoil soap to 10 gallons of water or a nicotine solution made by adding three-fourths of a pint of 40 per cent nicotine sulphate and 4 pounds of dissolved soap to each 50 gallons of water is reasonably effective. Spraying with water is a useful control measure, and the widespread adoption of the overhead sprinkler system for applying water to greenhouse crops has made it possible largely to control the red spider.

The linseed-oil-emulsion treatment suggested and brought into use by the Massachusetts Agricultural Experiment Station has proved to be a very effective control of the red spider. The emulsion is made of soap, linseed oil, and water. A stock solution may be prepared by dissolving 1 pound of soap in 1 gallon of boiling water and diluting this with 1 gallon of cold water, after which 1 gallon of raw linseed oil is added and the mixture emulsified by pumping it back into the container through the use of a bucket or other spray pump. This stock solution may be diluted to about 20 times its volume, as such a mixture has proved effective in killing the red spider. Applied as a spray the emulsion covers the pests with a waxy oil, which holds them fast, eventually killing them.

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[1] *Tetranychus telarius* L.

GREENHOUSE WHITE FLY.

Few insects are more widely found in greenhouses than this white fly.[2] It is particularly destructive to the greenhouse cucumber, and unless vigorously combated it will soon ruin the crop. The mature insect may be recognized by its characteristic white color and its habit of flying when plants on which it is working are disturbed. The immature forms may be found on the under side of the leaves as translucent whitish bodies. The standard remedy is fumigation with hydrocyanic-acid gas, which is generated by using sodium cyanid and sulphuric acid and water. Repeated fumigations with 1 ounce of sodium cyanid, 1½ fluid ounces of the acid, and 2 fluid ounces of water to each 4,000 cubic feet of air space will rid the house of this pest. Cucumber foliage is very susceptible to the action of the gas, and serious injury to the plants may result if the above amount of cyanid is exceeded. *The cyanid and the resulting gas are deadly poisons and must be employed with the greatest caution.* Before attempting to use this method, secure a copy of Farmers' Bulletin 880, entitled "Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-Acid Gas," which gives directions for its application.

APHIDS OR PLANT-LICE.

Several species of aphids, or plant-lice, attack greenhouse cucumbers. These insects sap the vitality of the plants by sucking the juices from the foliage and stems. They are controlled by contact sprays, such as nicotine or soap solutions. Consult Farmers' Bulletin 914, entitled "Control of the Melon Aphis," for detailed information. Another method of controlling these pests is to fumigate the houses with smoke from burning tobacco stems or from some of the special nicotine-saturated papers now on the market. Hydrocyanic-acid-gas fumigation, as recommended above for the white fly, will also control aphids.

STRIPED CUCUMBER BEETLE.

This cucumber beetle attacks greenhouse cucumbers, but such infestations are usually caused by growing outdoor cucumbers or cucurbits near the greenhouse, these acting as sources of infestation for the indoor plants. Obviously, there is more danger of infestation with the fall crop, as the insects may come from outdoor cucurbits near by. The most effective control measures are to avoid growing outdoor cucurbits near the greenhouse and the destruction of old plants which may serve as harboring places for the insects.

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[2] *Aleyrodes vaporariorum* W.

Consult Farmers' Bulletin 1322, entitled "The Striped Cucumber Beetle and How to Control It," for detailed information.

Sanitation is the most effective method of controlling greenhouse pests. Soil sterilization and the destruction of old plants by fire are also effective as control measures.

Growers of greenhouse cucumbers should supply themselves with the Farmers' Bulletins mentioned above, which may be obtained free on application to the Division of Publications, Department of Agriculture, and they may also take up matters regarding insect control with the Bureau of Entomology, Department of Agriculture. If there is any doubt as to the identity of the insects causing the injury, living specimens should be furnished to that bureau.

DISEASES OF GREENHOUSE CUCUMBERS.

Practically all the diseases that attack cucumbers in the open may affect the crop when grown in the greenhouse. Sanitation, or keeping the house clean, and the prompt destruction by fire of diseased and dead plants, coupled with the steam sterilization of the soil at least once each season, will do much toward controlling the various diseases affecting greenhouse cucumbers. Should anthracnose, downy mildew, or angular leaf-spot appear, overhead irrigation should be discontinued or used very sparingly.

ANTHRACNOSE.

This fungous disease[3] attacks the leaves, stems, and cucumbers and is characterized by dead brownish spots, one-fourth to one-half inch or more in diameter, on the leaves, and by discolored and shrunken areas on the stems. Thorough spraying with Bordeaux mixture made according to the 4–4–50 formula will check the disease and prolong the life of the plants. Spraying should be begun when the first signs of disease are seen and repeated at weekly intervals. More important, however, is the use of new or steam-sterilized soil for the crop and the treatment of the seed for five minutes before planting in a 1–1,000 mercuric-chlorid solution, followed by thorough washing in water.

DOWNY MILDEW.

This disease[4] is characterized by numerous small, angular, yellowish spots on the leaves, which eventually cause the yellowing, curling, and death of the foliage. It is one of the most serious diseases of greenhouse cucumbers. Fluctuating temperature, improper ventilation, and excessive moisture all tend to aggravate the trouble. Thorough and timely spraying with 4–4–50 Bordeaux mixture helps to control mildew, but the careful management of the houses and the crop as preventive measures is to be recommended. The mildew is usually introduced into the houses from near-by greenhouses or fields where a diseased vine crop has been grown. Hence, the disease may be prevented from getting into the houses by keeping vine crops as far as possible from them.

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[3] Caused by *Colletotrichum lagenarium* (Pass.) Ell. and Hals.

[4] Caused by *Pseudoperonospora cubensis* (B. and C.) Rostow.

BACTERIAL WILT.

Bacterial wilt [5] often affects greenhouse cucumbers. It is characterized by a wilting of the plants, due to the growth of bacteria in the water vessels, and is similar in appearance to the wilting caused by lack of water. Death soon results, and the disease often causes serious losses. Bacterial wilt is transmitted from plant to plant, as well as carried over winter, by the striped cucumber beetle, and possibly by other insects, and rigid control of these will materially aid in controlling the disease. Wilted plants should be promptly pulled and burned or buried.

MOSAIC.

Cucumber mosaic is characterized by mottling and curling of the leaves, by warted, mottled, or irregular fruits, and by a dwarfed growth of the plant. Like many other mosaic diseases, it is caused by a virus which is transmissible in the juice of diseased plants carried by insects, chiefly striped beetles and aphids and by pickers. It is carried over winter in the seed of the wild cucumber, in the perennial rootstocks of the common milkweed, and in other host plants, but not to any important extent in the seed of the cultivated cucumber. The best control measures known include the prompt removal of diseased plants, the digging up and burning of wild cucumber, milkweed, pokeweed, and other overwintering host plants in the vicinity, and the control of insects which spread the disease. It is also very important to avoid carrying it from plant to plant during pruning or picking operations.

ROOT-KNOT.

Greenhouse cucumbers are subject to serious injury by nematodes,[6] or small eelworms, which infest the roots of this any many other plants, causing characteristic knots or swellings. These interfere with the normal activities of the plant, and unless protective measures are taken the pest will overrun the whole range of greenhouses, making it impossible to produce good crops. Steam sterilization of the soil is an effective control measure, and practically all growers of cucumbers in greenhouses look upon sterilization as a necessary measure. Owing to the habit of the pest of penetrating deeply into the soil, and even under the walks, it is necessary that the sterilization be very thorough.

Certain other less serious diseases may attack the cucumber in the greenhouse, but these may ordinarily be controlled by proper greenhouse management, including soil sterilization, ventilation and sanitation, and seed treatment.

HARVESTING, GRADING, AND PACKING.

Under ordinary conditions, about 90 days elapse from the time the seed is sown until the harvesting of the crop begins. The cucumbers must be gathered at frequent intervals, as their market qualities are injured by leaving them on the vines too long, and the vines themselves are hurt by leaving the cucumbers until the seeds begin to harden. It is usually sufficient to go over the vines every other day. The cucumbers are removed by severing the stems with a knife. It is not advisable to break off the cucumbers, as this may injure both the vines and the cucumbers. In small houses it is a simple matter to carry the crop to the packing house, but in the case of large houses some form of conveyance, such as a truck running on the concrete walks of the house, must be employed. A hand truck suitable for the transportation of the cucumbers to the packing house is shown in Figure 16, which also illustrates the methods followed in grading and packing the product. As a rule, three or four grades are established, according to quality. The No. 1 grade consists of those cucumbers that are straight, uniformly cylindrical, and of uniform color. The No. 2 grade consists of those varying slightly in shape and color from the best grade, while the No. 3 grade contains those enlarged at the ends or enlarged or constricted in the middle and not of uniform color, while the other grade includes the nubbins, used mainly for salads, where the shape does not make much difference. Figure 17 shows the four grades into which the product of a large Middle West greenhouse range is divided. The variety in this case is the Telegraph. The kind of packages used depends upon local customs and upon the demands of the markets to be supplied. In some cases splint baskets holding from two to three dozen cucumbers are employed. In other cases crates holding from five to six dozen are used. Figure 18 shows the containers used by the concern whose packing room is shown in Figure 16. The boxes are used for the best of the crop and hold from one to two dozen cucumbers. The hampers and barrels are employed for the

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[5] Caused by *Bacillus tracheiphilus* Erw. Smith.

[6] *Heterodera radicicola* (Greef) Müller.

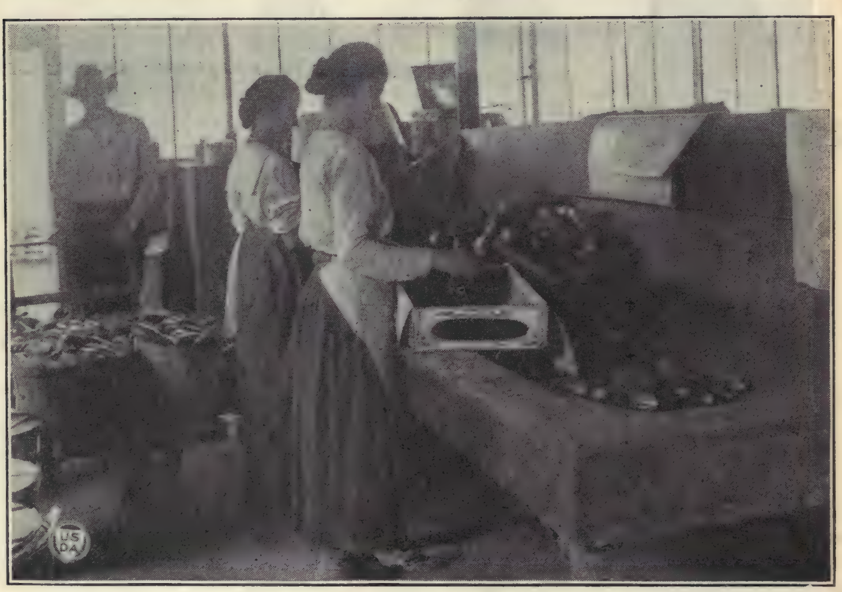

FIG. 16.—The packing house of a large greenhouse range producing great quantities of cucumbers. The truck is used to transport the cucumbers from the greenhouse to the packing house. Only the best grades are packed in the boxes, the poorer grades being packed in hampers and barrels.

other grades. A large producer in northern Ohio packs his entire product in barrels, but it is carefully graded and only one grade placed in a container. In the Boston district, greenhouse cucumbers are packed in standard bushel lug boxes. The use of attractive containers, such as the boxes shown in Figure 18, is a material aid in disposing of the crop.

Ready access to markets which will easily consume the product of the range is desirable. These markets may be within trucking distance or they may be several hundred miles away but readily accessible by fast express service. Some growers ship as many as 150 barrels of cucumbers a day during the height of the season, and it is necessary that proper marketing facilities be available to handle these large quantities. Much of the product is handled on a commission basis, but in some of the larger sections cooperative marketing associations are in existence, and these maintain in each of the larger distributing points an agent, whose duty it is to distribute the crop to the best advantage.

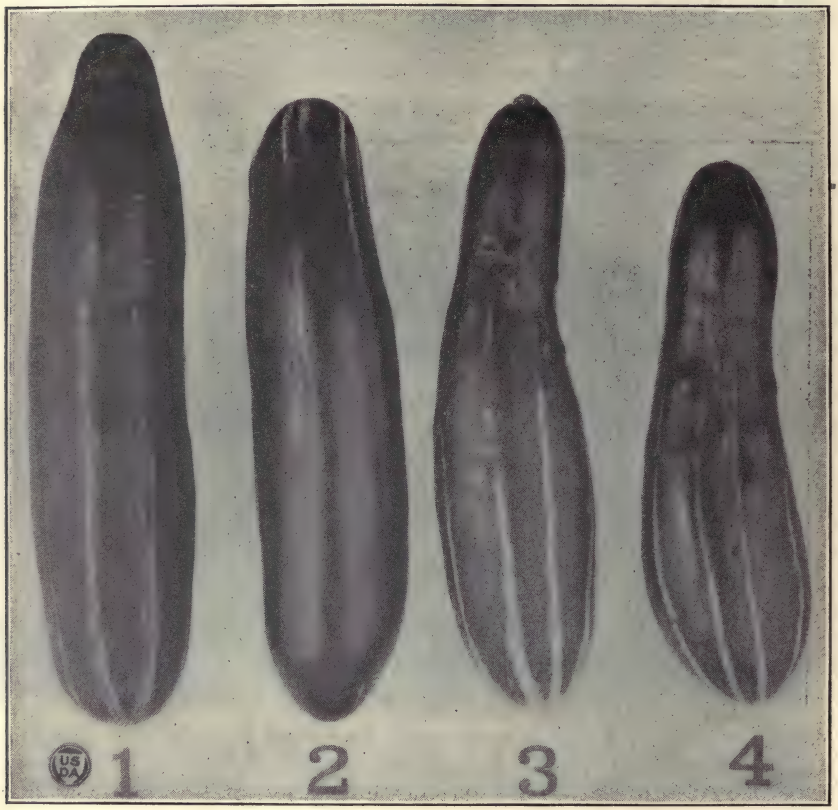

FIG. 17.—Four grades of cucumbers into which the product of a large greenhouse range is divided. The best grades are packed in boxes, while the poorer grades are sold in hampers or in barrels. The size, shape, and color of the cucumbers are taken into account in making the grades.

YIELDS AND RETURNS.

The yields depend upon the care and attention given the crop. Under favorable conditions from 30 to 60 cucumbers may be expected from each plant. As many as 100 to 120 cucumbers have often been gathered from a single plant. As a rule, heavier yields will be secured from spring-sown cucumbers than are had from a fall or winter crop. The price received varies greatly and may range from as low as 50 cents to as much as $2 per dozen. The higher prices are received for the best grades and for that portion of the crop produced at the season when there is the greatest demand for a high-class product. During the later portion of the season of the spring crop the price sometimes goes so low that it does not pay to continue picking and packing the cucumbers.

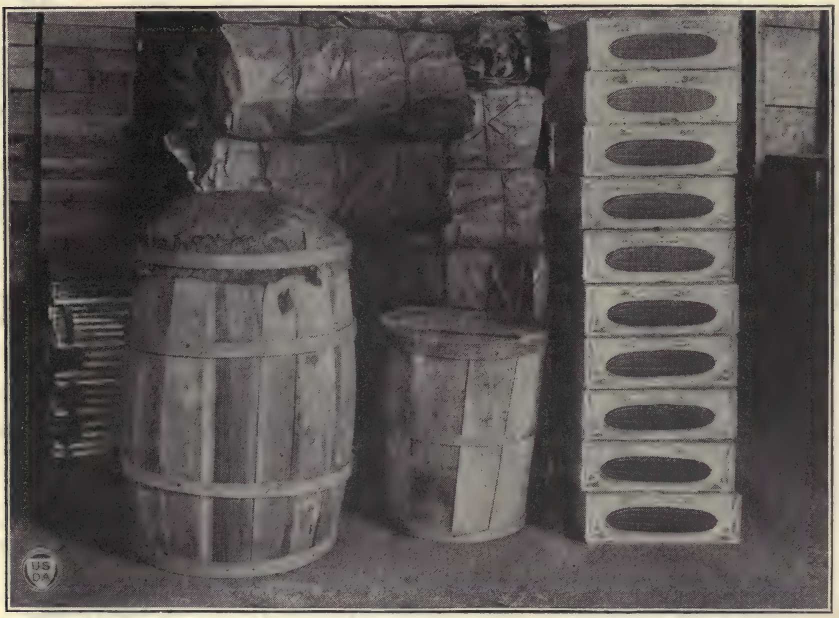

FIG. 18.—Containers used in a large cucumber-growing plant for marketing the product.

No comprehensive statement can be made relative to the returns to be expected from a cucumber crop. It is safe to say that the grower who produces maximum yields of high-quality cucumbers will ordinarily make a satisfactory profit. Very high returns per acre of ground inclosed in greenhouses are essential, on account of the cost of houses and equipment and the heavy expenses necessary for fuel, labor, manure, fertilizer, packages, etc.

The cucumber is one of the most promising of the vegetable forcing crops, but it can be successfully produced only by paying close attention to all the details of this highly specialized industry.

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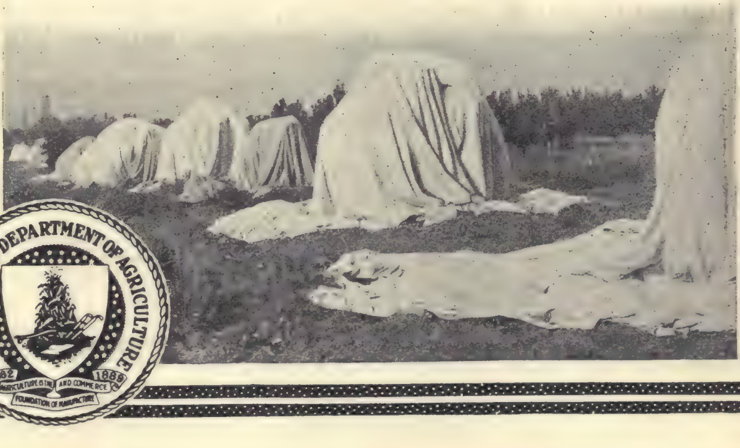
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1321

FUMIGATION OF CITRUS TREES FOR CONTROL OF INSECT PESTS



FOR the control of scale insects, growers of citrus fruits in California have for the last 30 years depended upon fumigation of the trees with hydrocyanic-acid gas. A tent is first drawn over the tree and the gas is produced or liberated within the tent. With proper dosage and under proper conditions, the scales are killed and the tree is seldom injured.

Three methods of producing and applying the gas are set forth in this bulletin. The first is the pot method, in which the gas is produced within the tent by adding cyanid to water and sulphuric acid in a glazed earthenware jar. This method some years ago was largely superseded by the fumigating-machine method, in which cyanid solution is added to sulphuric acid and water in a machine mounted on wheels, and the gas is conducted into the tent through a hose. The third method, introduced within the last few years and now very extensively used, is the "liquid gas" method, in which liquid hydrocyanic-acid, carried in a machine, is forced into the tent through a fine nozzle, forming a mist which quickly becomes gas.

Details of these methods, with dosage tables and some necessary cautions, are given in the following pages.

This bulletin supersedes Farmers' Bulletin 923, Fumigation of Citrus Trees.

Washington, D. C. July, 1923

FUMIGATION OF CITRUS TREES FOR CONTROL OF INSECT PESTS.[1]

R. S. WOGLUM,[2] formerly *Entomologist, Tropical and Subtropical Fruit Insect Investigations, Bureau of Entomology.*

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WHAT CITRUS FUMIGATION IS.

THE use of hydrocyanic-acid gas in fumigating plants for the destruction of insect pests is one of the most important discoveries in the field of insect control. No other known gas having so wide a range of usefulness so quickly destroys insect life. Its value as a fumigant was discovered in 1886 by the late D. W. Coquillett, an agent of this department, while investigating the control of certain scale insects on citrus trees in California. The success of the gas treatment in that State was immediate and its development rapid, and soon all other methods of controlling citrus scale insects were almost completely supplanted. Nearly every year new sprays have been offered in competition with the gas method, but fumigation has outlived them all and hydrocyanic-acid gas is to-day, even as 30 years ago, by far the most widely used and most effective of all insecticides for scale control on citrus trees on the Pacific coast. In Florida[3] cyanid fumigation has been amply demonstrated several times but never adopted commercially as in California, owing largely to more restrictive climatic conditions. This method of scale control is now used in South Africa, Egypt, Spain, Australia, and Japan.

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[1] For a detailed report on fumigation in California see Bulletin 90 of the Bureau of Entomology, United States Department of Agriculture, published in 1911. This may be obtained for 20 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

[2] Mr. Woglum resigned from the department September 11, 1920.

[3] Fumigation with wet tents is impracticable because of difficulty of handling as well as of plant injury. In Florida, the normally high humidity, by producing wet tents, seriously restricts fumigation. Short working hours mean higher labor costs and more equipment. Furthermore, the physiological condition of citrus trees under Florida conditions appears to render them more susceptible to cyanid gas injury than under the drier climate of California.

CAUTION.—*Hydrocyanic-acid gas is colorless and is one of the most deadly poisonous gases known. It has an odor much like that of peach pits. In case of accidental inhalation of the gas, the person affected should be kept in the open air and required to walk to increase respiration.*

The directions given in this bulletin are specifically for the control of scale and related insects infesting citrus trees, although, with proper modification, they will apply to the control of similar insects on other trees and plants.

Orchard fumigation for the control of citrus scale insects consists of covering trees with cloth tents, and liberating hydrocyanic-acid gas beneath these tents. The exposure of the insects to this gas for a definite period, varying with the insects to be controlled, will result in their destruction. In this connection the effect of the gas upon the plants, as well as upon the insects, must be considered.

EQUIPMENT REQUIRED IN ORCHARD TREATMENT.

Orchard fumigation requires special equipment, comprising tents, poles for placing them over the trees, containers for the chemicals, and apparatus for generating the gas.

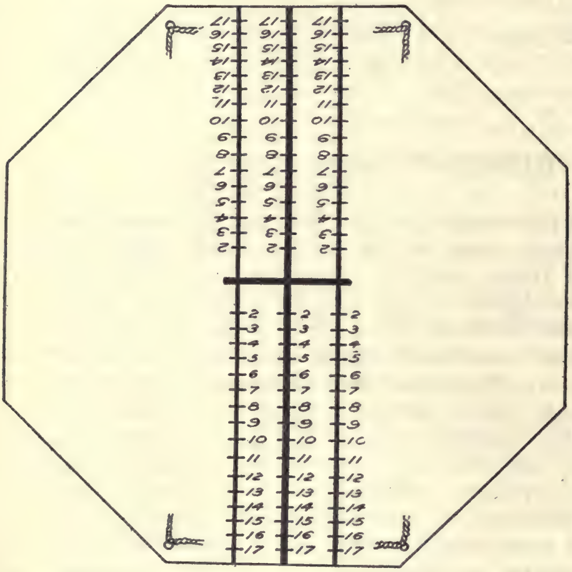

FIG. 1.—Fumigation tent marked according to the Morrill method.

TENTS.

Flat cloth tents of octagonal design (Fig. 1) are employed for orchard fumigation. To avoid waste of cloth in cutting, these tents are constructed of standard sizes based on the distance between parallel sides. The sizes commonly used are 36, 41, 43, 45, 48, 50, 52, 55, 64, 72, and 81 feet.

In purchasing tents the orchardist should be guided by the size of the trees to be fumigated, making due allowance for their normal growth. Tents 36 or 41 feet in size should be used for citrus trees up to 10 feet in height; 41, 43, or 45 foot tents for trees 11 to 15 feet in height; 45, 48, or 52 foot tents for trees 16 to 20 feet in height; and 55, 64, or 72 foot tents for trees 21 to 25 feet in height.

The number of tents required depends largely upon the size of the trees and the acreage to be treated. In California the commercial outfit contains from 15 to 90 tents; the average outfit, however, consists of from 45 to 70 tents 41 to 48 feet in size. The usual length of exposure is one hour, and under the most favorable conditions one tent will cover from 12 to 14 trees a night, though the average for the whole fumigation season approximates from 5 to 7, and the grand total for the season from 375 to 450, in the case of most commercial outfits. A few outfits which are used over an abnormally long season have exceeded the maximum stated.

MATERIAL.

Material for tents must be of the tightest possible weaves, comparatively light, and of sufficient strength to prevent tearing when trees are being covered. Heavy stiff tents are not only difficult to manipulate but they break branches, injure fruit, and, moreover, will not fit closely to the ground around the trees, thus permitting rapid escape of the gas.

The materials now in general use for sheet tents are 6½-ounce and 7-ounce special drill, 8-ounce double-filled duck, and 7-ounce and 8-ounce special Army duck. A special, closely woven, 8-ounce United States Army duck is recommended as superior to any other cloth for fumigation tents, as it is strong and durable and retains the gas much better than the other grades of cloth.

CONSTRUCTION.

Experienced tent or awning makers are competent to construct these tents.[4] In fact, several firms in this country, particularly in California, specialize in their construction. To secure a tent actually the size required, due allowance must be made for shrinkage of new cloth. For example, a 43-foot tent of new cloth will shrink approximately 3 feet in length and half a foot in width after becoming wet, and other sizes will be reduced proportionately. Some fumigators have their 45-foot tents made 48 feet in length to offset the shrinkage. Large, heavy tents are difficult to manipulate and undesirable, yet neither strength nor lightness should be unduly sacrificed in reducing weight. A method commonly adopted for 40-foot tents or larger is to construct the centers (full strips of equal length) of 8-ounce duck and the "wings" or "skirts" of 7-ounce duck or drill. Duck "skirts" are preferable to drill.

MARKING.

The prevalent system of fumigation requires special marking of the tents. Accurate marking is possible only after the cloth has been shrunk, which is easily accomplished by spreading the tents on a flat, open place where they can be saturated with water. Treatment for mildew, described later, also produces a shrinkage of the cloth. Untreated factory-marked tents require due allowance for shrinkage.

A plan of marking tents that was devised by Dr. A. W. Morrill[5] is shown in Figure 1. Three parallel lines running in the direction of the strips of cloth are graduated at intervals of 1 foot. The middle of each line is considered zero, and the numbering should be outward from this point. The distance between the parallel lines depends on the size of the tent. Three feet has been found to be an appropriate distance for tents up to 45 feet in size, and 4 or 5 feet in larger tents. The middle line should pass through the center of the tent. Where many tents are to be marked, a large stencil will facilitate the operation. The numerals should be at least 6 inches in height and can be made with printer's ink, lampblack and turpentine, or a soft, flexible, black paint.

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[4] A method of constructing fumigation tents is described in detail in Bulletin 90 of the Bureau of Entomology, United States Department of Agriculture.

[5] Morrill, A. W. Fumigation for the Citrus White Fly as Adapted to Florida Conditions. U. S. Dept. Agr. Bur. Ent. Bul. 76, p. 31. 1908.

Practice has brought about a modification of the original style of marking, so that to-day the three parallel lines are omitted, merely the figures and dashes, or the figures alone, retained. The figures in the parallel columns should not be the exact counterpart of each other, but each column should be so characterized by a difference in size or shape of numerals, or otherwise, as to enable the tape man readily to distinguish a particular column on opposite sides of a tented tree.

MILDEW PROOFING.

In a dry climate, such as prevails in California, tents are not usually treated to prevent mildew. The life of untreated tents in this climate usually is from four to six years, and depends for the most part upon the extent of their use, the care accorded them, the type of trees covered, and the type of surface soil in the orchards where used. A certain amount of deterioration from mildew has been reported by some fumigators, particularly those operating in the damper coastwise districts, or during the rainy season. Mildew proofing of tents under such conditions would appear advisable. In Florida, as well as in tropical countries where tents become wet every night, treatment to prevent mildew is necessary.

The dipping of tents in a solution of tannin to render them proof against mildew has been done for a long time and is very effective. Tents are dipped in a vat containing hot tannin solution (40 pounds extract of oak bark to about 100 gallons of water) for about 30 minutes and then spread on the ground to dry. Contrary to the usual belief, the tannin treatment does not increase the gas-holding power of the tent, though it appears to increase its wearing quality. A less expensive treatment than tannin, and one which does not change the color of the fabric, consists of sal soda, 5 pounds; tartaric acid, 10 ounces; and zinc sulphate, 5 pounds, to 200 gallons of water. The latter solution has been reported as extensively used in Florida for mildew proofing canvas used for various purposes. Solutions containing copper salts should be avoided, as they are toxic to trees in connection with cyanid gas. The common practice is to dip tents in a large vat. A more expeditious and possible practical method is to spread out a tent on the ground and apply the solution with a power sprayer. After the first tent has been thoroughly saturated, a second can be spread over the first, and this wetted. In this way several tents can be piled one upon the other. The tents should remain in the pile over night to become thoroughly saturated. The next day they can be spread out to dry. The cost of this method should not exceed $1 or $2 a tent. The most convenient time to mildew proof tents is at the close or the beginning of the fumigation season.

GAS PROOFING.

Many efforts have been made in years past to gas proof fumigation tents, but no satisfactory method was found for gas proofing without rendering their use impractical under the rough handling to which they are subjected in orchard fumigation. During 1921, following experimentation by Prof. H. J. Quayle, of the California Citrus Experiment Station, with a tent made from a discarded Army balloon, there was developed a gas-tight cover made of Army duck uniformly coated on one side with thin rubber. The California Fruit Growers' Exchange put a set of these tents of 48-foot size into the field to determine their commercial value. These tents became permeable to cyanid gas shortly after being placed in the field and the leakage increased with use. The following deductions were made after six months' continuous operation in covering upward of 25,000 trees: (1) The manipulation of gas-tight tents commercially is practicable; (2) tents must be entirely gas tight to be superior to army duck for commercial use; (3) moisture and sunlight restrict field operations with gas-tight tents more than with canvas covers; (4) the injury factor is somewhat magnified with gas-tight covers; (5) the superiority of scale kill or greater uniformity of results was neither proved nor disproved. Of the various materials tried two-ply balloon or balloonet fabric alone was found entirely gas tight, and stood up well during the winter. Hot summer weather, however, broke down the rubber even in this very high-grade cloth. The very considerable experience in California with gas-tight tents would appear to indicate that this type of cover is not likely to displace the present canvas tents for commercial fumigation.

POLES AND DERRICKS.

Either two wooden poles or two derricks are used in placing tents over trees.

The lengths of poles commonly used are 14, 16, or 18 feet. Twenty-foot poles are occasionally used for large trees. These poles average 2¼ to 2½ inches in diameter, are rounded, and made of straight-grained, well-seasoned hard pine free from knots. In the Gulf Coast States seasoned cypress is a cheap and satisfactory material for poles. Cypress wood does not need to be milled, as the trees grow straight and slender. It is advisable to have an extra set of poles on hand in case one set is broken. The lower end should be sharpened slightly so that it will hold firmly in the ground, while the upper end, to which a rope is attached for the purpose of erecting the poles, is commonly narrowed bluntly or rounded in accordance with one of the methods suggested in Figure 2.

The sizes of rope most preferred are ¾, ⅞, or 1 inch. Cotton rope has been found easier to handle and more durable than hemp, but the latter is selected by most fumigators because of its lower cost. The rope should be approximately 3 feet longer than the pole. A stout piece of rawhide is sometimes substituted for the first 3 feet of rope adjacent to the pole, as this section, being half hitched over the tent each time the pole is used (see Fig. 21), suffers the most wear.

In covering very tall trees it is necessary to use derricks with uprights about 3 feet higher than the tallest trees. Derricks usually are made of the same material as poles and have a framework attached to the bottom to prevent slipping and to confine the movement to one of two directions when the other end is raised. A rope and pulley arrangement is placed at the top for raising the tent, and the rope should be approximately three times the length of the pole. The uprights in common use average between 25 and 35 feet in length, with the top 2½ to 3½ inches and the bottom 3½ to 4½ inches in diameter. The construction is shown in Figure 3. The desire for speed has led to the tendency in recent years in California to avoid derricks whenever possible and cover larger trees with poles. Poles 22 and even 24 feet long are now in use. The latest device for covering large trees is to attach a simple pulley to the top of a long pole.

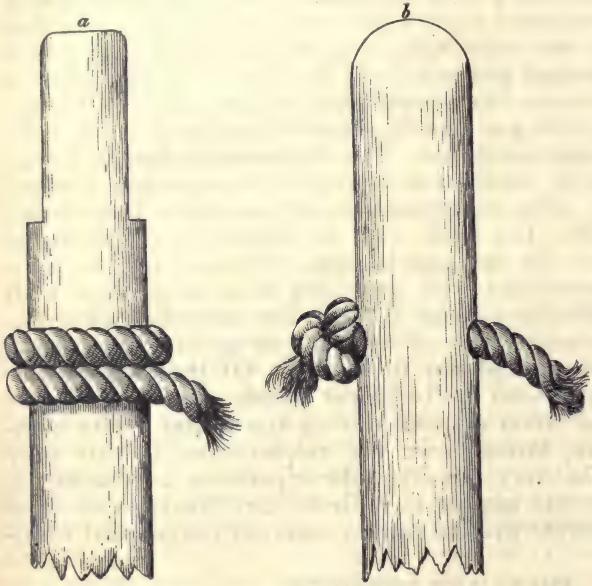

FIG. 2.—Ends of hoisting poles used in placing tents over trees: *a*, Used with tents where rings are present; *b*, used with tents having no rings.

EQUIPMENT FOR THE POT SYSTEM.

GENERATORS.

Under the pot system of fumigation earthenware vessels, heavily glazed to prevent weakening by action of the acid, are required for generating hydrocyanic-acid gas under the tent. The type of vessel long used in California is shown in Figure 4. Covers are considered a nuisance by many practical fumigators and are seldom used. They are to be recommended, however, as they minimize tent burning, distribute the gas rapidly toward the bottom of the tree, and largely eliminate injury to foliage immediately above the generator. The generator commonly used holds from 1½ to 2 gallons, although a 1-gallon size is used occasionally for small trees and a 3-gallon size for very large trees.

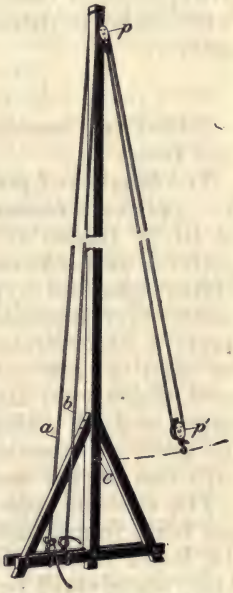

FIG. 3.—A derrick, showing rope and tackle arrangement for raising tents: *a*, Guy rope used in holding derrick in upright position; *b*, pulling rope for raising tent; *p*, upper pulley; *c*, ring to which lower pulley, *p′*, is hooked when not attached to tent.

CHEMICAL WAGONS.

An apparatus of some sort is required in orchard work for carrying from tree to tree the chemicals necessary in fumigation. Figure 5 represents a specially equipped cart, which was introduced in California by this department in 1908 and which subsequently gained wide usage. Such a cart can be drawn either by the men of the outfit or by a horse. Most fumigators prefer to use a horse-drawn wagon rather than a cart for carrying the chemicals, with the result that a number of very original and ingenious combinations have been devised.

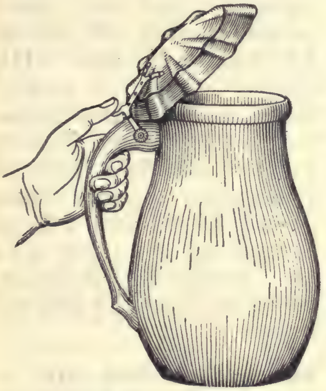

FIG. 4.—A fumigation generator, with cover device.

OTHER EQUIPMENT.

Sulphuric acid comes in large iron drums. A large Stilson or monkey wrench is needed for opening the drum. The acid is easily removed through a special spout or can be siphoned through a hose. As sulphuric acid is very caustic, great care should be exercised in its handling and use. A 1-gallon earthenware or porcelain-lined acid pitcher is needed, and a large lead, copper, or iron funnel. Some fumigators prefer small acid containers in the field and for this purpose use 10-gallon glass carboys in stout wooden frames with handles, as shown in Figure 6, or 2-gallon earthenware jugs. Other necessary apparatus includes a tin-lined cover for cyanid case, barrels for

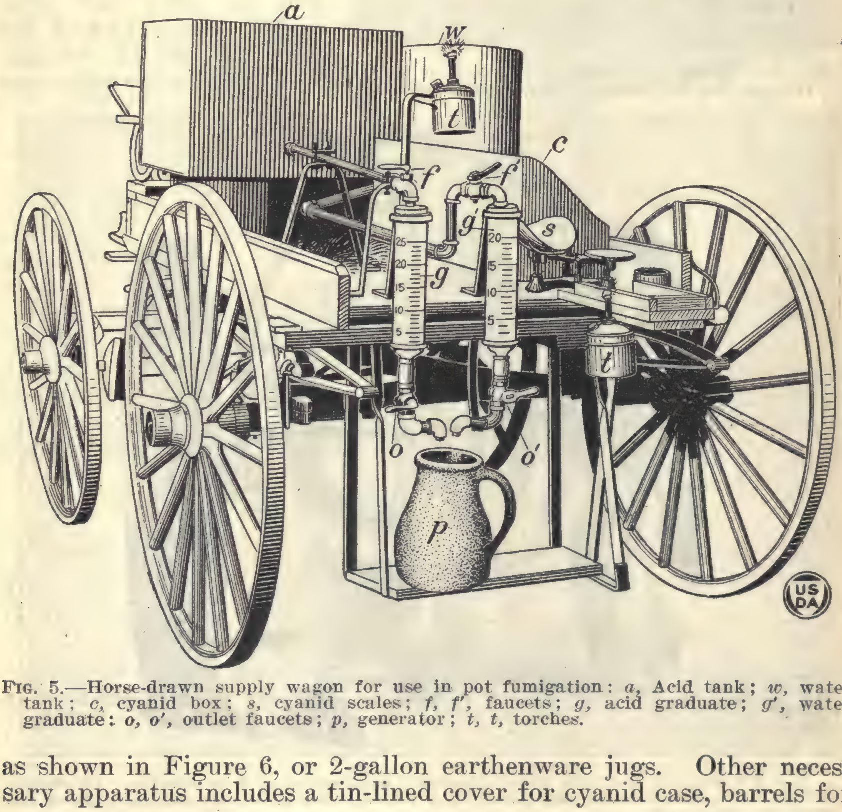

FIG. 5.—Horse-drawn supply wagon for use in pot fumigation: *a*, Acid tank; *w*, water tank; *c*, cyanid box; *s*, cyanid scales; *f, f′*, faucets; *g*, acid graduate; *g′*, water graduate: *o, o′*, outlet faucets; *p*, generator; *t, t*, torches.

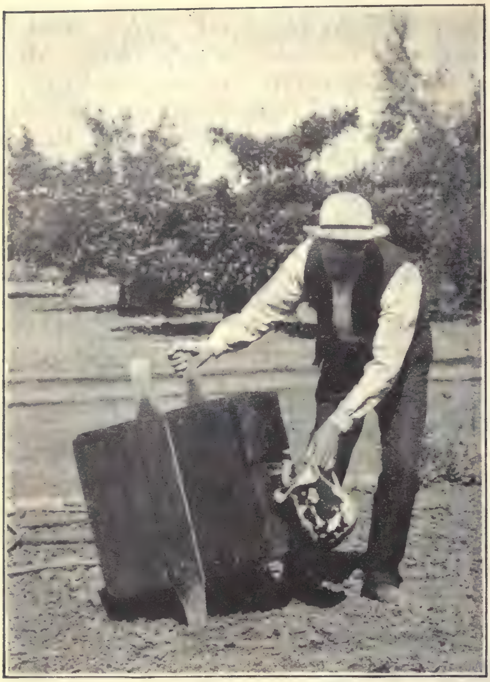

Fig. 6.—Carboy with handles attached to facilitate pouring the acid and carrying the carboy.

water, large water pail, lantern or torch, coal-oil or carbide light or flashlight for tape man, heavy rubber gloves, 50, 66, or 75 feet of tape with special catch for attachment to tent, thermometer, hygrometer, shovel, hatchet, schedule cards of fumigation dosage, blank record sheets, and a large hinged-top wooden box for protecting miscellaneous equipment when not in use.

EQUIPMENT FOR THE MACHINE METHOD.

A large horse-drawn machine for generating cyanid gas outside the tent came into use in 1912 and by 1916 had completely supplanted the pot method of fumigation. The apparatus now

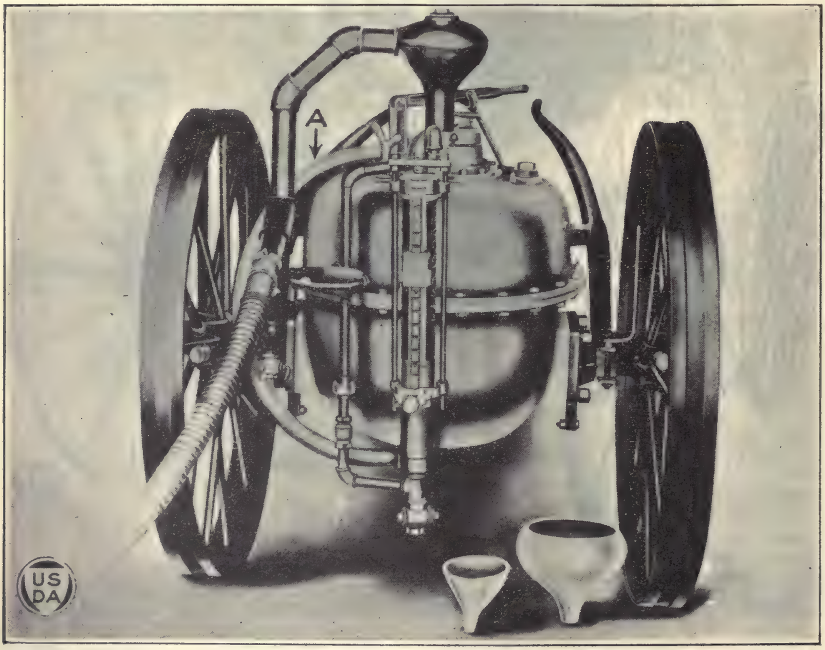

Fig. 7.—A fumigating machine which generates gas from cyanid in solution. By substituting a T-connection for the elbow at *A* an easy means is afforded for testing the accuracy of delivery.

used in machine generation is illustrated in Figure 7. It consists of two tanks, one above the other, the lower containing a mixture of equal parts of sulphuric acid and water, while the upper contains the cyanid solution. By the action of a suitable pump measured quantities of the cyanid solution are forced into the tank containing the acid-water mixture, and the gas instantly generated escapes to the tented tree through a large hose.

Other equipment needed in machine generation includes cyanid solution tanks (Fig. 8), solution drums, and much of the miscellaneous apparatus listed under the pot system.

EQUIPMENT FOR THE LIQUID HYDROCYANIC-ACID METHOD.

The equipment for liquid hydrocyanic-acid fumigation is decidedly less cumbersome than for either the pot or machine method. Special applicators of 2 or 3 gallons' capacity are used which measure each charge in cubic centimeters, after which it is forcibly ejected through a nozzle and broken into a fine mist beneath the tented tree. Several different applicators have been placed on the market since the introduction of liquid gas. The two types which survived the season of 1921, and proved more accurate than any previously used, are illustrated in Figures 9 and 10.

The liquid is delivered in 80 or 100 pound drums. Special faucets are supplied for drawing off the material. A wooden standard is needed for supporting the drum while filling the applicator; insulated drums or containers for holding drums which will afford protection from high temperatures are advocated when liquid gas is held in the field during the daytime. A small amount of miscellaneous equipment is needed and a box for holding it.

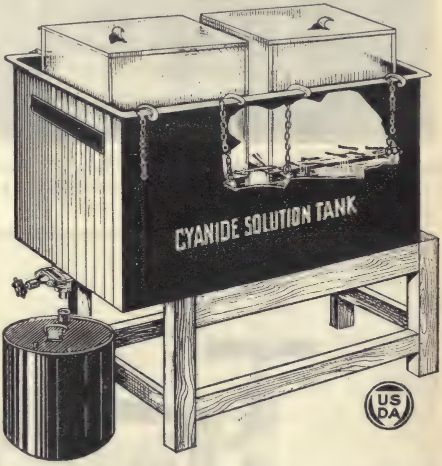

Fig. 8.—Cyanid solution tank for dissolving cyanid to be used in fumigating machines. Below, a 5-gallon field container.

CHEMICALS OF FUMIGATION.

Cyanid of sodium or cyanid of potassium, sulphuric acid, and water are necessary for the generation of hydrocyanic-acid gas.

CYANID.[6]

Either sodium cyanid or potassium cyanid in the crystal form can be used in fumigation. Potassium cyanid was used exclusively up

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[6] All recommendations made in this bulletin are for sodium cyanid 96 to 99 per cent pure. For the use of potassium cyanid see Bulletin 90 of the Bureau of Entomology, United States Department of Agriculture.

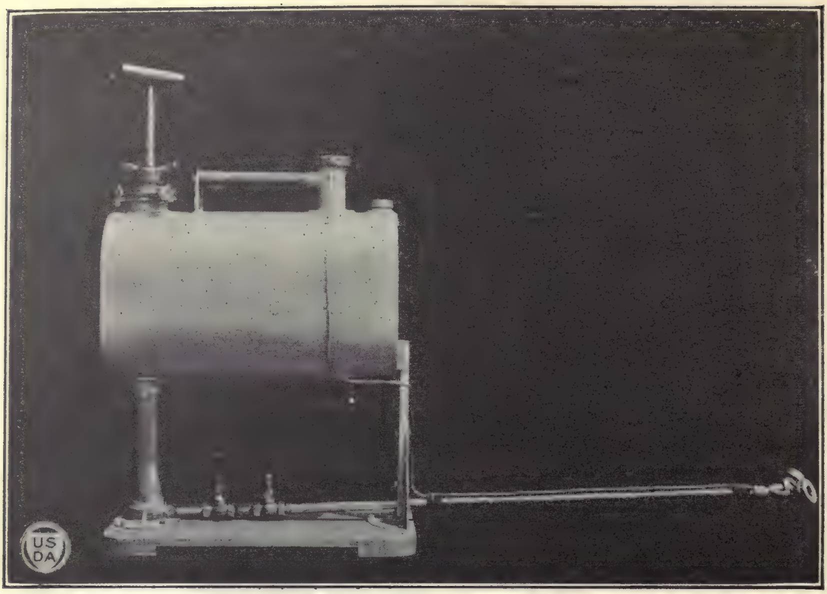

FIG. 9.—A machine for applying liquid hydrocyanic acid beneath tented trees by the movement of a plunger.

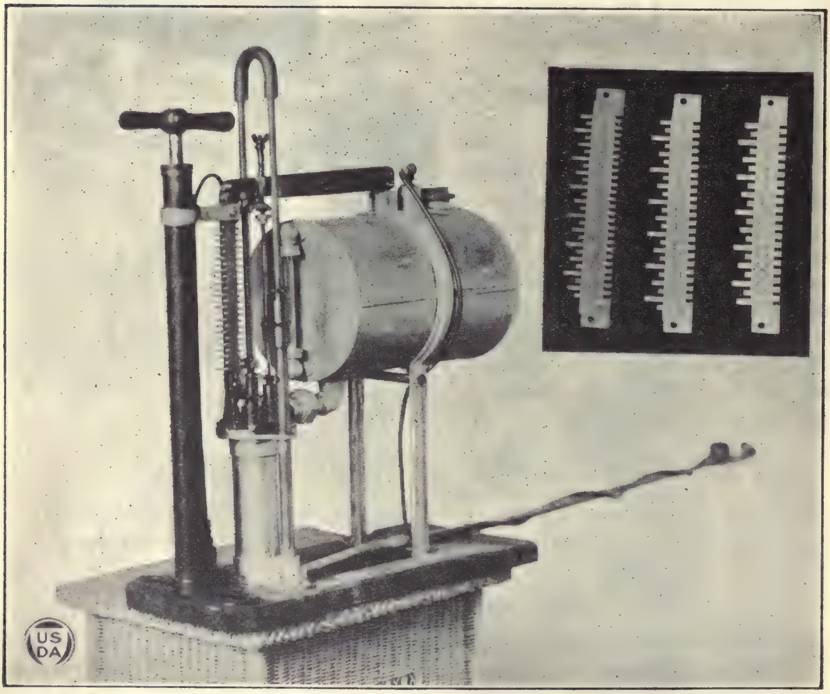

FIG. 10.—A liquid-gas machine introduced in California during 1921. The liquid is forced out of the measuring chamber by air pressure. Inset: Interchangeable gauges which deliver 88, 100, or 111 per cent dosages.

to 1909, but since that date has been superseded by sodium cyanid.[7] Considering the world's limited supply of available potassium salts, there is little likelihood that potassium cyanid will be used again extensively in orchard fumigation.

Sodium cyanid for fumigation purposes should be of 96 to 99 per cent guaranteed purity, thus containing not less than 51 per cent of cyanogen. It should be in large lumps, not finely pulverized. The volume of gas liberated is governed directly by the purity of the cyanid. The dosages for different insects are based on pure cyanid, and poor results are likely to follow if impure chemicals are used. **Too much stress can not be placed on the importance of purchasing high-grade cyanid,** in view of the fact that much of this material on sale by retail druggists is very impure, and thus unsuited for fumigation.

The purchaser will be protected if he obtains a cyanid guaranteed under the insecticide act. The analysis on the label should indicate not less than 51 per cent cyanogen.

Cyanid is decomposed under moist conditions and should be protected from dampness by storage in a tightly covered tin box. If a box of cyanid is to stand for several days without being used, fill the empty space with old cloth or burlap to prevent exposure of the cyanid to air. Unused cyanid at the end of the season's work should be placed in as small a tin as possible and tightly sealed. High-grade cyanid for chemical use can be purchased in cases of 50, 100, or 200 pound sizes.

SULPHURIC ACID.

A commercial sulphuric acid (H_2SO_4) 92 to 94 per cent pure (66° B.), free from nitric acid, arsenic, lead, and zinc, should be used. It does not matter whether the acid is made from pyrites or from pure brimstone, provided impurities are eliminated. Acid is usually purchased in large iron drums holding from 1,500 to 2,000 pounds. It can be purchased also in glass carboys of about 10 gallons capacity. Pure acid is colorless and about twice as heavy as water, its specific gravity being 1.83. If stored in iron drums it frequently has a slightly milky color, especially toward the bottom of the drum. This color is due to sulphate of iron, produced by acid coming in contact with iron either before or after the acid is placed in the drum. This sediment in no way affects the value of the acid, unless it is present in excessive quantities.

Acid may be removed from drums in the field, although it is preferable to convey it thither in 10-gallon glass carboys. Acid will burn the flesh or destroy the clothing quickly, and care should be observed in its handling. Should acid come in contact with the flesh, wash the affected parts quickly with water. The use of rubber gloves in handling the acid containers is advisable.

HOW TO GENERATE HYDROCYANIC-ACID GAS.

THE POT METHOD.

Fumigation with hydrocyanic-acid gas was developed to its present stage of efficiency under the pot method (Fig. 11), the gas being generated in a vessel under a tent by combining cyanid, sulphuric acid, and water in a glazed earthenware vessel. For each ounce, by weight, of sodium cyanid, 1½ ounces, liquid measure, of sulphuric acid and 2 ounces of water are required to evolve the maximum volume of gas and carry the reaction to completion. This is known as the 1–1½–2 formula. This gives satisfactory results under field conditions, although some fumigators prefer to use 1¼ ounces of sulphuric acid to each ounce of sodium cyanid. For large dosages the latter formula appears quite satisfactory, but in the case of small dosages undissolved cyanid frequently remains and is a cause of complaint.

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[7] See Bulletin 90, part 2, of the Bureau of Entomology, page 83.

MIXING THE CHEMICALS.

In mixing the chemicals the water should be measured first and poured into the generator. Next, the acid should be measured and added to the water. This acid-water solution will become very hot. Then the generator should be placed at once beneath the tented tree, well back toward the trunk, and the required amount of cyanid added. The operator can avoid contact with the hydrocyanic-acid gas, which is liberated immediately, by placing the cyanid into the acid-water solution at arm's length. The foregoing procedure should be adhered to closely. **Acid must not be poured into a cyanid-water mixture, as a violent reaction will result.**

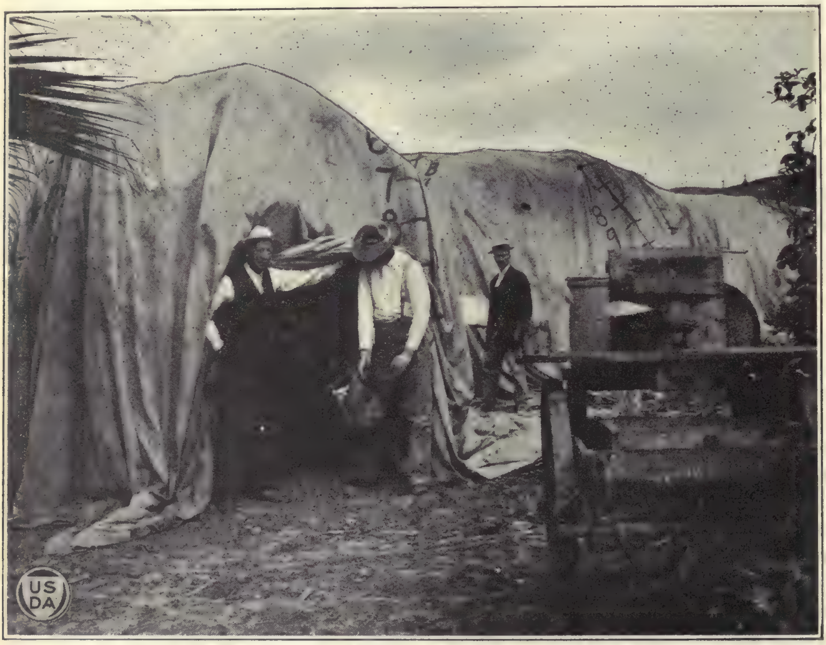

Fig. 11.—The pot system: Dosing a tree. This view also shows the scheduler securing the measurements of the next tree in the row.

The acid-water mixture never should be allowed to cool before the cyanid is added, as a heated solution is necessary for a complete generation of gas. The cyanid should be in lumps averaging about the size of an English walnut, and small pieces should be used only in small dosages. A charge composed entirely of powdered cyanid results in a violent reaction, which is dangerous.

SMALL DOSAGES.

In field fumigation generators of the same size are used frequently with both small and large dosages. In general the results from dosages not exceeding 3 ounces of cyanid are less satisfactory than those from larger dosages, since with the former there is often an incomplete generation of the gas. For the best possible generation there must be enough liquid in the generating vessel to cover the cyanid completely. This is not always accomplished by following the recommended formula with 1-ounce to 3-ounce dosages in flat-bottomed jars unless the cyanid used is in very small pieces and the jar is placed on edge.

Chemical tests have shown that an extra ounce of acid and 2 extra ounces of water added to the quantity required by the formula will give the needed amount of liquid and will in no way affect the liberation of gas in 1, 2, and 3 ounce dosages.

NATURE OF THE RESIDUE.

The residue from the generation of hydrocyanic-acid gas is very poisonous and usually is in the form of a bluish or greenish liquid consisting of water, sulphate of sodium, sulphuric acid, and hydrocyanic acid. Vegetation, such as cover crops, is destroyed by the action of this residue, and even surface roots of citrus trees in loose sandy soil are likely to be injured severely.

Some orchardists demand that the residue be carried off the field, but this precaution is unnecessary in ordinary fumigation where small dosages are used. The residue should never be emptied near the base of a tree, however, but midway between two rows previously fumigated. Care should be exercised that the tents do not come in contact with the residue.

THE MACHINE METHOD.

The pot method of fumigation was almost completely supplanted in 1915 to 1917 through the introduction of portable machines for generating gas outside of the fumigating tent. This development is especially interesting in that it is a return to the principle of generation followed by the late D. W. Coquillett in 1886, when he discovered the efficacy of hydrocyanic-acid gas in the control of insect pests of citrus trees. Mr. Coquillett's procedure consisted in bringing the cyanid dissolved in water in contact with sulphuric acid in a vessel outside the tent, and conducting the resulting gas under the tent by means of a pipe. In 1889 this procedure gave way to the pot method described in foregoing pages.

The first fumigating machine was introduced in 1912, and a second type in 1915. This second type (Figs. 7 and 12) has completely supplanted all other machines.

DISSOLVING THE CYANID.

A heavy sheet-steel or sheet-iron tank is used for dissolving cyanid. (Fig. 8.) The cyanid is purchased in 200-pound containers. Numerous slashes are cut along the lower edge and in the bottom of the container with a hatchet, and a small opening in the top. The case is then suspended in a tank containing 50 gallons of water, or two cases in 100 gallons of water. Experience has demonstrated that by suspending the cases so that only a small quantity of the cyanid comes in contact with the water, thereby insuring rapid circulation of the water, the cyanid is dissolved rapidly and without agitation. By this method it requires from three to four hours to dissolve a 200-pound case of cyanid.

In the process of dissolving, the saturated solution falls to the bottom of the tank, and unless agitated the solution at the bottom of the tank will be strong and that at the top weak. It is necessary, therefore, that the solution be thoroughly stirred each time as soon as all the cyanid is dissolved and before any solution has been removed from the tanks. Once thoroughly agitated it will remain of a uniform strength throughout for a long time. Cyanid solution deteriorates materially when exposed to direct sunlight, but when it is kept tightly covered in a cool place no deterioration takes place even if allowed to stand for several weeks. Determinations made by the Bureau of Chemistry of this department show that cyanid solution of the concentration of 1 ounce of commercial sodium cyanid to 2 ounces of water will crystallize at a temperature below 50° F. Instances of crystallization at low temperatures have been observed in commercial work. Such crystallization might take place at even a higher temperature in the case of concentrated solution at the bottom of the tank when stirring is neglected. When crystallization occurs the solution should remain unused until redissolved.

The preferred method is to dissolve the cyanid at the warehouse and transport it to the field in drums. If dissolved in the field the solution should be prepared during the day to guarantee complete solution when work is started.

When correctly made (at the rate of 4 pounds of cyanid to 1 gallon of water) the solution has a specific gravity of 1.173 at 80° F. Two hundred pounds of sodium cyanid dissolved in 50 gallons of water (rate of 1 ounce of cyanid to 2 ounces of water) increases the volume to 63 gallons, or about 26 per cent. One gallon of this solution contains about 3.2 pounds of solid sodium cyanid, or 1 pound of cyanid is equal to 0.315 gallon solution. Two and one-half ounces of solution are equal to 1 ounce solid sodium cyanid, and the delivery in the fumigating machine is graduated on this basis.

CHARGING THE MACHINE.

The cyanid solution is poured into the upper reservoir. Charged to full capacity, this holds 12½ gallons, equivalent to 640 ounces of solid sodium cyanid. The amount of acid and water to place in the lower reservoir is determined by the average dosage of the next trees to be fumigated and the number of trees in the row. (A row of thirty 12-ounce trees will require 2¼ gallons of acid and the same quantity of water.) Table 1 gives the calculated dosages of cyanid and acid to meet the requirements of different rows of trees. The water must always be poured into the fumigating machine first. The acid should be added just previous to putting the machine into action so as to get the full benefit of the generated heat.

TABLE 1.—*Ounces of cyanid and gallons of sulphuric acid required by the fumigating machine to fumigate various numbers of different-sized trees.*

TREES PER ROW	AVERAGE DOSE (OUNCES) OF CYANID PER TREE.											
	4	6	8	10	12	14	16	18	20	22	24	26
	TOTAL AMOUNTS OF CYANID AND SULPHURIC ACID REQUIRED.											
24	96 ¾	144 1	192 1¼	240 1½	288 1¾	336 2	384 2¼	432 2¾	480 3	528 3¼	576 3½	624 3¾
26	104 ¾	156 1	208 1¼	260 1½	312 2	364 2¼	416 2½	468 2¾	520 3¼	572 3½	624 3¾	
28	112 ¾	168 1	224 1½	280 1¾	336 2	392 2½	448 2¾	504 3	560 3½	616 3¾		
30	120 ¾	180 1¼	240 1½	300 1¾	360 2¼	420 2½	480 3	540 3¼	600 3¾	660 4		
32	128 ¾	192 1¼	256 1½	320 2	380 2¼	448 2¾	512 3	576 3½	640 3¾			
34	136 1	204 1¼	272 1¾	340 2	408 2½	476 3	544 3¼	612 3¾				
36	144 1	216 1½	288 1¾	360 2¼	432 2¾	504 3	576 3½	648 4				
38	152 1	228 1½	304 2	380 2¼	456 2¾	532 3¼	608 3¾					
40	160 1	240 1½	320 2	400 2½	480 3	560 3½	640 3¾					
42	168 1	252 1½	336 2	420 2½	504 3	588 3½						
44	176 1¼	264 1¾	352 2¼	440 2¾	528 3¼	616 3¾						
46	184 1¼	276 1¾	368 2¼	460 2¾	552 3¼	644 4						
48	192 1¼	288 1¾	384 2¼	480 3	576 3½							
50	200 1¼	300 1¾	400 2½	500 3	600 3½							
52	208 1¼	312 2	416 2½	520 3¼	624 3¾							
54	216 1½	324 2	432 2¾	540 3¼	648 4							
56	224 1½	336 2	448 2¾	560 3¼								
58	232 1½	348 2¼	464 2¾	580 3½								
60	240 1½	360 2¼	480 3	600 3½								

The upper figure in each square indicates the amount of cyanid and the lower figure the amount of concentrated acid required. The proper charge of acid is indicated at the intersection of the columns representing respectively the number of trees per row and the average dose per tree. For example, if a row has thirty-six 10-ounce trees 2¼ gallons of acid would be required. The amount of water used is ALWAYS EQUAL TO THE ACID, AND MUST ALWAYS BE PLACED IN THE MACHINE FIRST.

INITIAL CHARGE.

The generating cylinder of a fumigation machine before starting contains a large amount of air which must be displaced before the full charge of cyanid gas is available. Furthermore, the pipe between the pump and acid chamber must be filled with solution before the full charge is recovered. This pipe can be filled by placing the indicator on the 2-ounce mark and operating the pump until solution is forced into the acid chamber. Then generate a 4-ounce charge to displace the air in the chamber and hose. The fumigating machine is then ready for active duty.

OPERATION.

The figures on the solution-pump cylinder represent ounces of solid sodium cyanid, and these correspond to the figures on dosage charts. Each downward stroke of the pump forces a charge of cyanid into the acid reservoir and the chemical reaction and gas delivery are instantaneous, the gas passing through a hose leading to the tented tree. After a row of trees is dosed the residue has become exhausted and should be promptly removed. This residue contains both unused sulphuric acid and cyanid and should be dumped at a distance from the trees to avoid damage. If the machine is cleaned with water at frequent intervals, it will give best results. **Machines should also be tested occasionally so that their accuracy may be assured.**

RESULTS WITH MACHINE FUMIGATION.

Horticultural commissioners, fumigators, and orchardists largely agree that the general results in scale-insect destruction are as satisfactory with the machine method as with the pot system. An investigation of gas generation with the fumigating machine has shown that the average yield of gas with this machine approximates the amount evolved in pot generation.[8]

Nonuniformity of results is at times observed under any system of fumigation. In the case of the fumigating machine it has been most frequently reported that the first tree and the last few trees in the row are not fumigated effectively. This may be obviated, in the case of the first tree, by following the directions given under the heading "Initial charge." Unsatisfactory results on the last few trees indicate exhaustion or cooling of the acid solution toward the end of the row. The supply of acid must be adequate for the cyanid used in that row. A high temperature of the acid solution is best maintained by mixing the acid and water at the last possible moment before starting on the row and by proceeding from tree to tree without delay.

DOSAGE.

The same dosage schedules are used with machines as with pots, and all general recommendations for the procedure, avoidance of plant injury, and insect control are applicable for both pot and machine generation.

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[8] Young, H. D. The Generation of Hydrocyanic-Acid Gas in Fumigation by Portable Machines. Univ. Calif. Agr. Exp. Sta., Circ. 139, 1915.

MACHINE GENERATION VERSUS POT GENERATION.

The fumigating machine has certain advantages over the pot system. Tent burning is greatly lessened, cumbersome pots are eliminated, the chemicals of fumigation are handled more economically, the residue can be carried from the field, the generator's duties are less burdensome, and one man less is required on an outfit. There are, however, some disadvantages as compared with pots. One point particularly stressed by growers is that with pots the proper amount of chemicals measured out for each individual tree can be seen; whereas with the fumigating machine the improper functioning of the pump valve, which will lessen the dosage for one tree, might lessen the dosage for many successive trees. An irregularity in dosage might arise, also, through failure to dissolve the cyanid thoroughly, or to stir the stratified solution. Cooling of the acid solution sometimes happens in the machine and reduces the amount of gas expelled.

Considering advantages as well as disadvantages under actual operation, there is no doubt that the machine should be preferred to pots. The scale-kill is equally good, most of the disadvantages can be overcome by the careful operator, the fumigating machine is preferred by the fumigator, and the actual cost to the grower will average slightly less than for pot fumigation. The pot method is preferable for the private owner who has only a few trees to be treated, and for the fumigation of house-lot trees and trees in some terraced orchards.

THE LIQUID HYDROCYANIC-ACID METHOD.

The value of liquid hydrocyanic acid (popularly called "liquid gas") for the control of citrus pests was first demonstrated in 1916, and its subsequent history has been most interesting. The method became popular at once with fumigators through the substitution of a light, simplified apparatus (Fig. 13) for the very cumbersome equipment of the pot and fumigating machine systems (Fig. 12) and through the elimination of sulphuric acid in the field. The low degree of purity of the first liquid gas produced commercially retarded its early acceptance by growers, but by 1919 a uniformly high-grade product became available and as a result the liquid-gas method supplanted all others in orchard fumigation in California. When the results of the 1919 season had been studied, however, and it developed that there was much poor work, particularly in certain districts, considerable dissatisfaction arose and some growers returned to former methods. The results of 1920 in several districts were such as to intensify this dissatisfaction, and during 1921 the fumigating machine and pots were again extensively employed, approximately 15 to 20 per cent of all fumigation being done by these two methods.

Dissatisfaction with liquid gas is attributable to various circumstances but the chief fault probably lies in the method of application. The liquid became extensively used before a satisfactory applicator had been developed. The first applicators were more or less erratic in delivery and errors of 10 or even 20 per cent were not uncommon. Heavy cover crops in orchards seriously interfered with full volatilization of the gas expelled as a vapor through nozzles. The same was true of dense foliage, especially on cold, damp nights. There was much daylight fumigation with liquid gas during 1920, which resulted in an abnormal amount of injury. At the same time it was becoming increasingly apparent that the black and red scales in some districts were becoming more difficult to kill than in former years. All these conditions caused a retrial of former methods, particularly the pot system.

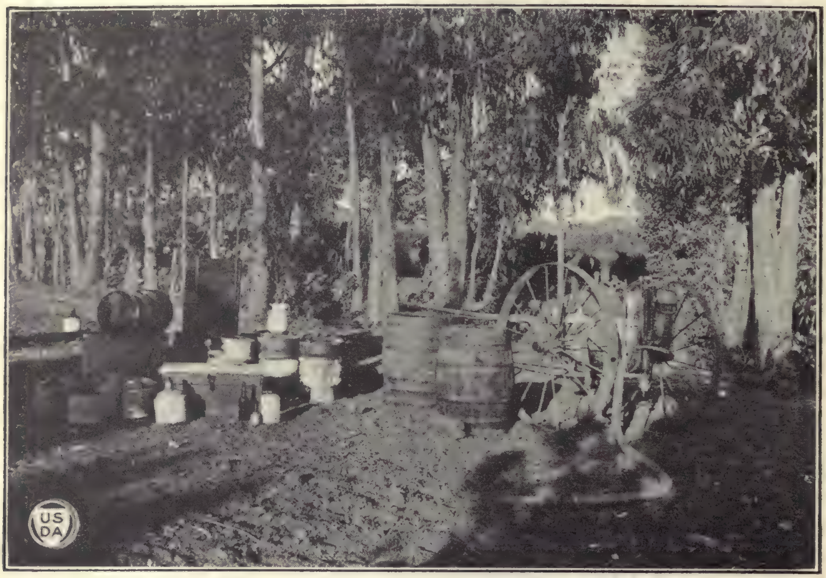

FIG. 12.—The equipment used by a fumigating machine outfit.

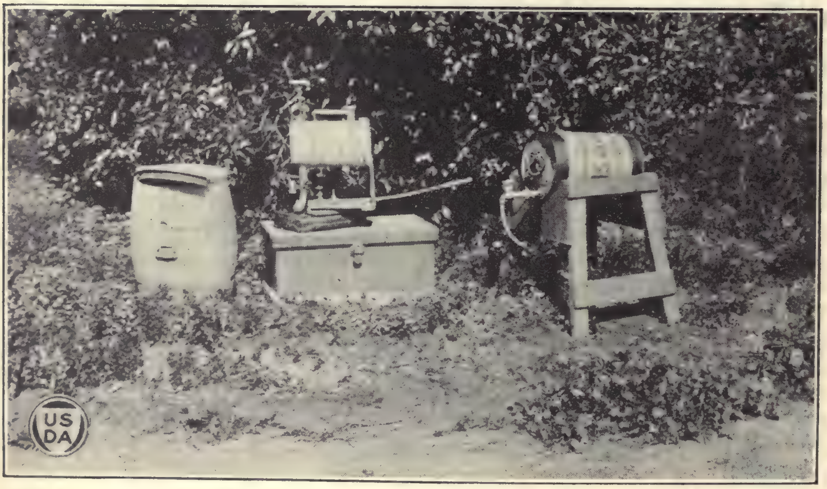

FIG. 13.—Equipment of a liquid-gas outfit, consisting of applicator, drum of gas on wooden standard, insulated container for drum, and wooden chest for miscellaneous articles.

APPLICATORS.

Liquid hydrocyanic acid is expelled by force through a fine nozzle as a mist which quickly becomes gas. Six different applicators operating on this principle have been developed and used since the introduction of liquid gas for fumigation in California; of these only two (figs. 9 and 10) have fully complied with commercial requirements in accuracy and practicability. The others have been abandoned. These applicators, with the exception of the type shown in Figure 9, all expel the liquid by means of compressed air supplied by a hand pump. They should be tested daily to establish accuracy of delivery. Water should be used for this purpose and can be caught from the nozzles in a funnel can, then measured in a cubic centimeter graduate. A constant and practical check on accuracy will follow the use of a platform scale for weighing the applicator when full before fumigating a row, and again when the row has been fumigated. The difference in weight will indicate the amount used. This can be checked against the actual amount called for by the dosage schedule, and the error of the pump, if any, detected. A rapid method to accomplish this is to add the dosages for the entire row, and then determine the weight for these dosages from Table 2. Suppose the total dosage for the row is 487 units of 16 cubic centimeters and the gas temperature 60° F. From the table, 400 equals 9.96 pounds, 80 equals 1.99 pounds, and 7 equals 0.17 pound, making a total of 12.12 pounds. The weight of the gas used as taken from this scale should closely approximate this total.

TABLE 2.—*Weight in pounds of 97 per cent liquid gas in measured quantities to correspond with the accurate delivery of applicators.*

[Calculations are for liquid gas at 40, 50, 60, or 70° F., when delivered in unit charges of 14, 16, 18, or 20 cubic centimeters.]

Number of unit charges.	40° F.				50° F.			
	14 c. c.	16 c. c.	18 c. c.	20 c. c.	14 c. c.	16 c. c.	18 c. c.	20 c. c.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03
2	.04	.05	.06	.06	.04	.05	.06	.06
3	.07	.08	.08	.09	.07	.08	.08	.09
4	.09	.10	.11	.13	.09	.10	.11	.13
5	.11	.13	.14	.16	.11	.13	.14	.16
6	.13	.15	.17	.19	.13	.15	.17	.19
7	.15	.18	.20	.22	.15	.18	.20	.22
8	.18	.20	.23	.25	.18	.20	.23	.25
9	.20	.23	.26	.29	.20	.23	.25	.28
10	.22	.25	.29	.32	.22	.25	.28	.32
20	.44	.51	.57	.64	.44	.50	.57	.63
30	.67	.76	.86	.95	.66	.76	.85	.95
40	.89	1.02	1.14	1.27	.88	1.01	1.13	1.26
50	1.11	1.27	1.43	1.59	1.10	1.26	1.42	1.58
60	1.33	1.52	1.72	1.91	1.32	1.51	1.70	1.89
70	1.56	1.78	2.00	2.23	1.54	1.76	1.98	2.21
80	1.78	2.03	2.29	2.54	1.76	2.02	2.26	2.52
90	2.00	2.29	2.57	2.86	1.98	2.27	2.55	2.84
100	2.23	2.54	2.86	3.18	2.21	2.52	2.83	3.15
200	4.45	5.08	5.72	6.36	4.41	5.04	5.66	6.30
300	6.68	7.62	8.58	9.54	6.62	7.56	8.49	9.45
400	8.90	10.16	11.44	12.72	8.82	10.08	11.32	12.60
500	11.13	12.70	14.30	15.90	11.03	12.60	14.15	15.75
600	13.36	15.24	17.16	19.08	13.23	15.12	16.98	18.90
700	15.58	17.78	20.02	22.26	15.44	17.64	19.81	22.05
800	17.81	20.32	22.88	25.44	17.64	20.16	22.64	25.20
900	20.03	22.86	25.74	28.62	19.85	22.68	25.47	28.35
1,000	22.26	25.40	28.60	31.80	22.05	25.20	28.30	31.50

TABLE 2.—*Weight in pounds of 97 per cent liquid gas in measured quantities to correspond with the accurate delivery of applicators*—Continued.

Number of unit charges.	60° F.				70° F.			
	14 c. c.	16 c. c.	18 c. c.	20 c. c.	14 c. c.	16 c. c.	18 c. c.	20 c. c.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03
2	.04	.05	.06	.06	.04	.05	.05	.06
3	.07	.07	.08	.09	.06	.07	.08	.09
4	.09	.10	.11	.12	.08	.10	.11	.12
5	.11	.12	.14	.16	.11	.12	.14	.15
6	.13	.15	.17	.19	.13	.15	.17	.18
7	.15	.17	.20	.22	.15	.17	.19	.21
8	.17	.20	.22	.25	.17	.20	.22	.24
9	.20	.22	.25	.28	.19	.22	.25	.27
10	.22	.25	.28	.31	.21	.25	.28	.30
20	.44	.50	.56	.62	.43	.49	.55	.61
30	.65	.75	.84	.93	.64	.74	.83	.91
40	.87	1.00	1.12	1.24	.85	.99	1.11	1.22
50	1.09	1.25	1.40	1.56	1.07	1.23	1.38	1.52
60	1.31	1.50	1.68	1.87	1.28	1.48	1.66	1.83
70	1.52	1.75	1.96	2.18	1.49	1.73	1.94	2.13
80	1.74	1.99	2.24	2.49	1.71	1.98	2.22	2.44
90	1.96	2.24	2.52	2.80	1.92	2.22	2.49	2.74
100	2.18	2.49	2.80	3.11	2.13	2.47	2.77	3.05
200	4.35	4.98	5.60	6.22	4.27	4.94	5.54	6.10
300	6.53	7.47	8.40	9.33	6.40	7.41	8.31	9.15
400	8.71	9.96	11.20	12.44	8.54	9.88	11.08	12.25
500	10.89	12.45	14.00	15.55	10.67	12.35	13.85	15.25
600	13.06	14.94	16.80	18.66	12.81	14.82	16.62	18.35
700	15.24	17.43	19.60	21.77	14.94	17.29	19.39	21.30
800	17.42	19.92	22.40	24.88	17.08	19.76	22.16	24.40
900	19.59	22.41	25.20	27.99	19.21	22.23	24.93	27.45
1,000	21.77	24.90	28.00	31.10	21.35	24.70	27.70	30.50

Nozzles should be inspected from time to time and kept clean. The nozzle arm should extend from 2 to 2½ feet beyond the tank, and the applicator when in action should be set close against the tent in order that the vaporized liquid may enter the open space surrounding the trunks rather than strike the foliage. The nozzle, however, should not be directed straight toward the trunks, particularly in the case of small trees, where it might cause injury. There should be enough strokes of the pump to insure total expulsion of the gas for each charge.

GENERAL CONSIDERATIONS.

Liquid hydrocyanic acid is supplied in California by two concerns. One produces the liquid from high-grade sodium cyanid, the other from a low-grade sodium-calcium cyanid.[9] The liquid hydrocyanic acid on the market during 1921 carried a guaranty of 96 to 98 per cent purity. This high-grade material is exceedingly volatile in warm, dry air, boiling at a temperature of about 80° F. Pressure sometimes develops at warm temperatures, which necessitates great care in opening drums to avoid sudden expulsion of the contents. Cool storage rooms are a necessity, and most concerns have special houses cooled by ice or a continuous spray of water on the drums. (Fig. 14.) Drums should be taken into the field as late as possible before starting work and covered with wet burlap sacks or placed in insulated containers or other protective device. An excellent plan is for the foreman to take the drums of gas on his way to work in a trailer attached to his automobile (Fig. 14). Direct exposure of drums to the sunlight should be avoided. Many citrus trees have been injured by placing drums of gas beneath them. Decomposition of liquid gas was frequent when first produced commercially, but the high-grade liquid gas now supplied can be stored for several months without deterioration.

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[9] A third concern was recently organized in California to manufacture hydrocyanic acid synthetically.

GAS DIFFUSION.

In the case of pot or machine generation a warm gas is injected beneath the tented tree and rapidly rises toward the top. The general result is a somewhat better scale kill toward the top than the bottom of the tree. This difference is most noticeable at the cooler temperatures of fumigation. On the other hand, when liquid gas is atomized beneath a tented tree it enters at a very cold temperature. Diffusion is slower than with a warm gas, the concentration becomes greater toward the bottom than the top, and correspondingly the scale kill at the bottom of the tree is superior to that toward the top.[10]

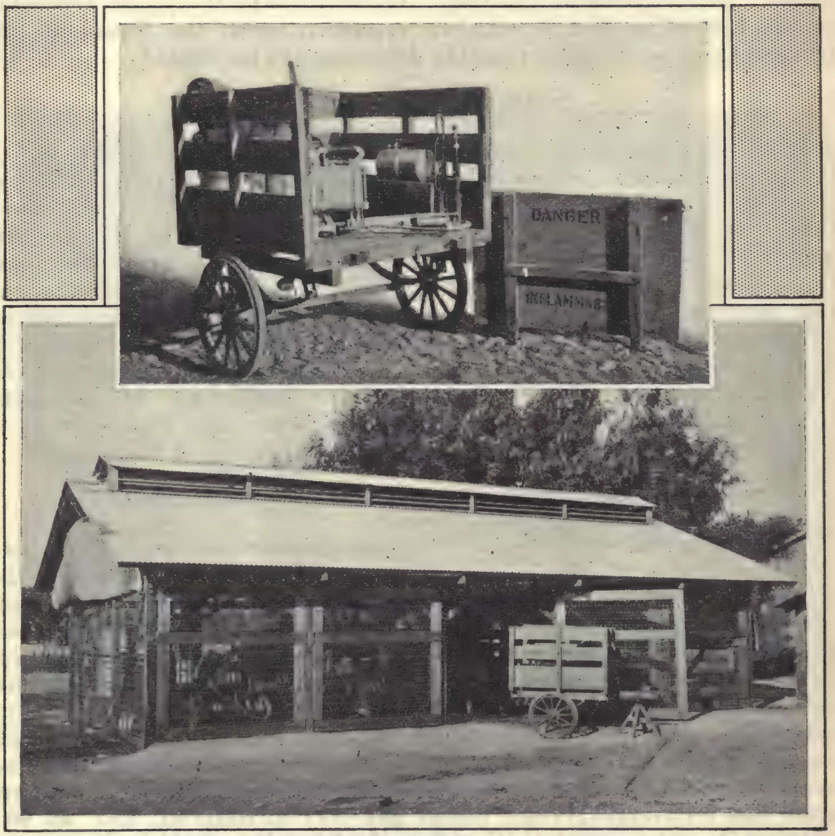

FIG. 14.—Type of house for storage of liquid hydrocyanic acid in California. A continuous spray of water falls over the exposed drums and acts to hold down the temperature. Note the type of trailer with heavily boarded sides for transporting drums and other apparatus between the storage commissary and each field outfit.

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[10] Woglum, R. S. Recent results in the fumigation of citrus trees with liquid hydrocyanic acid. *In* Jour. Econ. Ent., v. 12, No. 1, p. 122, 1919.

Temperature appears to exert a considerable influence on gas diffusion, and the popular impression is quite general that on very cold nights little gas rises to the top of large trees. This popular belief does not correspond fully with the results of Federal and State investigations, yet all agree that the scale kill is generally poorer under the liquid gas method at the low temperatures of 36° to 40° F. than at the highest temperatures of fumigation. These inferior results at low temperatures can not be attributed wholly to gas diffusion, for when poor scale kill occurs the condition is evidenced almost equally in all parts of the tree. Rather would it appear traceable to the loss of or the incomplete vaporization of the liquid at low temperatures and also to possible dormancy of the scale.

TEMPERATURE INFLUENCES.

It is the practice of many fumigators to discontinue the use of liquid gas at temperatures below 50° F. Others have adopted 45° as the low temperature limit. No conclusive data are available to show that scale kill at 45° is noticeably inferior to that at 50°, yet the writer advises stopping at 50°. Even when 50° is made the limit the temperature will frequently approach 45° before the tents on the last row are all removed. In fumigating at low temperatures an effort should be made to avoid cover-crop orchards. If the liquid, as it comes from the spray nozzles at cold temperatures, hits an obstruction, such as the cover crop or even the foliage of the citrus tree, it either freezes as ice or condenses as a liquid, which drops to the ground, thereby greatly reducing the strength of the charge.

LIQUID GAS VERSUS POTS AND FUMIGATING MACHINES.

The comparative values of the liquid-gas method, the pot method, and the method using the fumigating machine greatly concern the citrus industry in California at the present time. An unusual amount of dissatisfaction with fumigation results has arisen among growers in recent years. Several districts in which the scale several years ago was more or less successfully fought with a moderate dosage are now experiencing difficulty in controlling the scale with very heavy dosages. When fumigation was then needed only every other year it is now necessary to treat the trees every year and sometimes even twice in the same year. This extreme dissatisfaction with results has culminated since liquid gas was introduced, and, as was natural in such a case, the liquid method has been held in large part responsible for the present situation.

The California Experiment Station and the United States Department of Agriculture have carefully investigated fumigation with liquid gas and agree that if fumigation is conducted at warm temperatures and the work accurately done the results with liquid gas are equally as good as with pots or the fumigating machine. In fact, the results of certain experiments, comparing pot fumigation and that with liquid gas, show that in general the results with liquid gas are more uniform than with pots. The observations of most fumigators and of local horticultural officials who have inspected much work done commercially by all of these methods lead to the conclusion that liquid gas is as effective in scale kill as either of the other methods, particularly during the regular autumn season.

In cold weather the present method of applying liquid gas appears at times to give somewhat inferior results to the pot or fumigating-machine method. This is due to the loss of material from contact with foliage, etc., whereas with a hot gas there is no loss from this source. An increased dosage might partially offset this loss. An attempt has been made to avoid this inferiority of liquid gas in cold, damp weather by carrying on daylight fumigation during the late fall and winter. Most winter fumigation with liquid gas is now confined to the daytime, when the trees are dry and the air warm. This particular inferiority of liquid gas arises not from the material itself but from the method of application. The writer is fully convinced that the present outstanding need of the liquid-gas system is a practical apparatus which will convert the liquid to gas before it enters the tent, and that the liquid-gas method will not completely supplant the other methods until the principle of atomizing is superseded by one of complete gasification. Machines which will vaporize liquid gas have been constructed. One type of vaporizer (Fig. 15) was tried by several fumigators, including the writer, during the season of 1921, but failed to give complete satisfaction, chiefly because of small capacity and lack of dependability. This work, however, did prove that liquid hydrocyanic acid can be safely gasified in the field by heat, and it should be only a matter

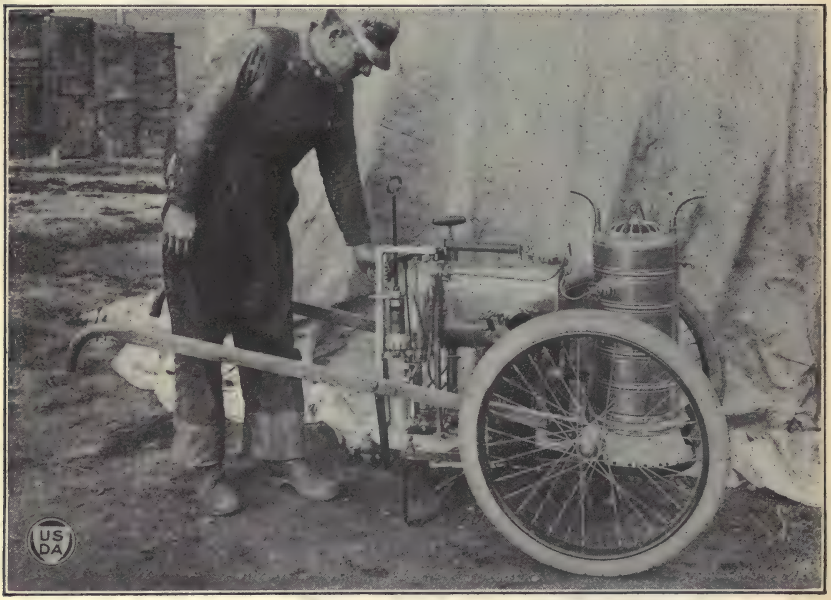

Fig. 15.—A machine for vaporizing liquid hydrocyanic acid, used in California during 1921. The measured liquid is passed through coils of pipe jacketed in hot water. Heat is supplied by a gasoline burner. Gasification is immediate.

of time before a thoroughly practical and perfected machine for this purpose will be developed; in fact, an important advance in this direction appears already to have been made in the machine shown in Figure 16, which was introduced during the season of 1922. Other vaporizers are in course of development.[11]

PROPERTIES OF LIQUID GAS.

Very little has been published on liquid hydrocyanic acid, and data of value in connection with the use of this material are for the most part not readily accessible. A few data needed by fumigators are presented in Tables 3, 4, and 5.

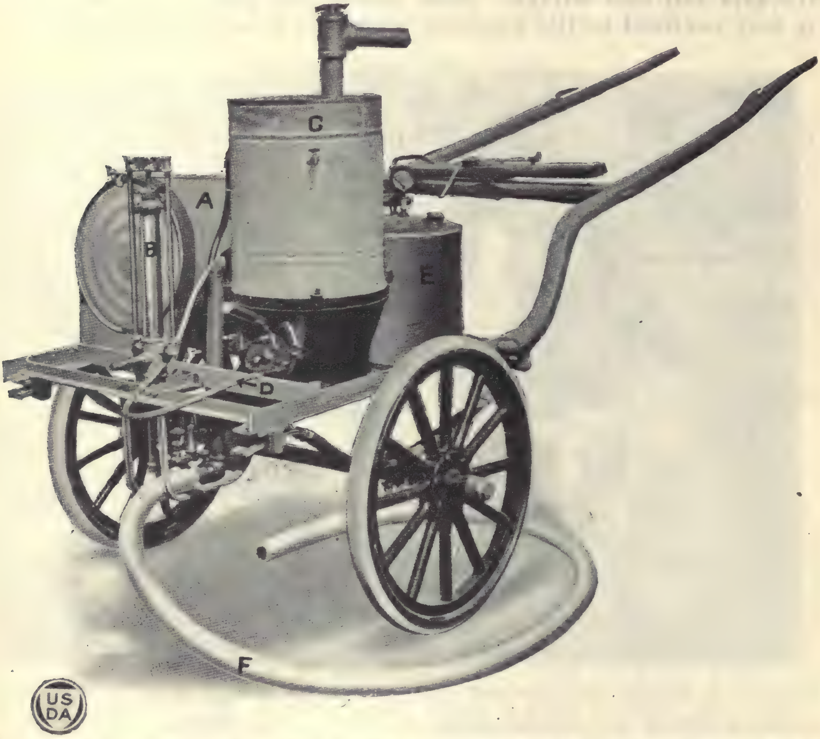

Fig. 16.—A horse-drawn vaporizing machine introduced during 1922. The liquid gas is used directly from field drums, *A*. The principle of vaporization was adapted from the machine shown in Figure 15. *B*, Measuring apparatus; *C*, hot-water jacket; *D*, gasoline feed to burner; *E*, gasoline tank; *F*, outlet hose for cyanid gas.

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[11] Since preparing the manuscript of this bulletin a vaporizer of unique design and practical merit has been introduced and successfully tried. This vaporizer is illustrated in Figure 17. The apparatus is so arranged on a platform that it can be mounted intact on an automobile chassis and the machine operated from the rear platform. The very interesting part of this apparatus is that the exhaust gas from the motor, mixed with air, is passed into a burner, and the combustible mixture reignited. It is stated that a temperature of approximately 1450° F. is generated within the stove. A metal coil is located within the stove. As each charge of fumigant is forced into this coil it instantly vaporizes into gas and is discharged through a tube beneath the tented tree at a very high temperature. The manufacturer of this machine recommends a mixture of liquid hydrocyanic acid and water rather than the 96 to 98 per cent material commonly used, maintaining that a hot, moist gas promises a quick uniformity of distribution within the tented inclosure. The machine has changeable measuring devices for different schedules. Special safety containers form a part of this equipment. By removing the special platform, after the fumigation season is over, the chassis is left in its original state, available for general use.

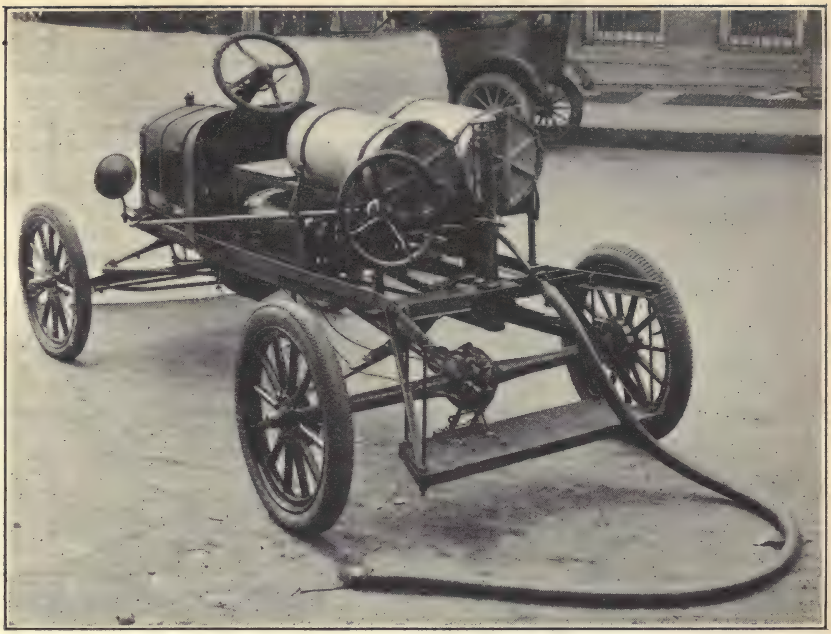

FIG. 17.—A special machine for vaporizing liquid hydrocyanic acid. The apparatus is so arranged on a platform that it can be mounted intact on an automobile chassis. An intense heat for vaporizing the liquid fumigant results from burning a mixture of the exhaust gas of the motor and air. The operator handles the apparatus and drives the automobile from the rear platform.

TABLE 3.—*Properties of liquid hydrocyanic acid.*[1]

WEIGHT OF 1 GALLON AT 60° F.

Per cent purity.	Weight in pounds.
99	5. 828
98	5. 855
97	5. 883
96	5. 911
95	5. 939

VOLUME OF 1 POUND OF 96 AND 98 PER CENT HYDROCYANIC ACID AT TEMPERATURES FROM 40° TO 79° F.

°F.	96 per cent (cubic centimeters).	98 per cent (cubic centimeters).
40	626	632
50	633	639
60	639	645
70	646	652
79	653	659

POUNDS OF 98 PER CENT HYDROCYANIC ACID REQUIRED TO FUMIGATE 100 TREES, USING UNIT CHARGES OF 18 CUBIC CENTIMETERS.

[1 pound 98 per cent hydrocyanic acid (60° F.) contains 36 18-cubic-centimeter unit charges.]

	Pounds.
100 8-charge trees	22. 25
100 10-charge trees	27. 8
100 16-charge trees	44. 5

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[1] One gallon of water weighs 8.329 pounds.

TABLE 3.—*Properties of liquid hydrocyanic acid*—Continued.

COMPARISON OF GAS FROM POT GENERATION WITH EQUIVALENT IN LIQUID GAS.

[Based on chemical determinations.]

1 ounce of 97 per cent sodium cyanid 93 per cent gas generation equals 20.44 cubic centimeters liquid gas 98 per cent at 60° F.

1 ounce of 98 per cent potassium cyanid 93 per cent gas generation equals 15.54 cubic centimeters liquid gas 98 per cent at 60° F.

CYANID EQUIVALENTS IN LIQUID GAS AS BASED ON FIELD RESULTS IN SCALE CONTROL.[2]

1 ounce of 97 per cent sodium cyanid is equivalent to 18 cubic centimeters 96 per cent to 98 per cent liquid gas.

1 pound of 96 per cent to 98 per cent liquid gas is equivalent to 2¼ pounds 97 per cent sodium cyanid.

TABLE 4.—*Specific gravity table for determining the percentage of liquid hydrocyanic acid at different temperatures.*[1]

Observed specific gravity.	Observed temperature in degrees Fahrenheit.																				
	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50
	Percentage of liquid hydrocyanic acid.																				
0.695	98.1	98.4	98.6	98.8	99.0	99.3	99.5	99.7	....	....	....	....	....	....	....	....	....	....	....	....	....
0.696	97.8	98.1	98.3	98.5	98.7	99.0	99.2	99.4	99.6	....	....	....	....	....	....	....	....	....	....	....	....
0.697	97.5	97.8	98.0	98.2	98.4	98.7	98.9	99.1	99.3	99.6	99.8	....	....	....	....	....	....	....	....	....	....
0.698	97.2	97.5	97.7	97.9	98.1	98.4	98.6	98.8	99.0	99.3	99.5	99.7	99.9	....	....	....	....	....	....	....	....
0.699	96.9	97.2	97.4	97.6	97.8	98.1	98.3	98.5	98.7	99.0	99.2	99.4	99.6	99.8	....	....	....	....	....	....	....
0.700	96.6	96.9	97.1	97.3	97.5	97.8	98.0	98.2	98.4	98.7	98.9	99.1	99.3	99.5	99.7	....	....	....	....	....	....
0.701	96.3	96.6	96.8	97.0	97.2	97.5	97.7	97.9	98.1	98.4	98.6	98.8	99.0	99.2	99.4	99.6	99.8	....	....	....	....
0.702	96.0	96.3	96.5	96.7	96.9	97.2	97.4	97.6	97.8	98.1	98.3	98.5	98.7	98.9	99.1	99.3	99.5	99.8	....	....	....
0.703	95.7	96.0	96.2	96.4	96.6	96.9	97.1	97.3	97.5	97.8	98.0	98.2	98.4	98.6	98.8	99.0	99.3	99.5	99.8	....	....
0.704	95.4	95.7	95.9	96.1	96.3	96.6	96.8	97.0	97.2	97.5	97.7	97.9	98.1	98.4	98.6	98.8	99.0	99.2	99.5	99.7	99.9
0.705	95.1	95.4	95.6	95.8	96.0	96.3	96.5	96.7	96.9	97.2	97.4	97.6	97.8	98.1	98.3	98.5	98.7	98.9	99.2	99.4	99.6
0.706	94.8	95.1	95.3	95.5	95.7	96.0	96.2	96.4	96.6	96.9	97.1	97.3	97.5	97.8	98.0	98.2	98.4	98.6	98.9	99.1	99.3
0.707	94.5	94.8	95.0	95.2	95.4	95.7	95.9	96.1	96.3	96.6	96.8	97.0	97.2	97.5	97.7	97.9	98.1	98.3	98.6	98.8	99.0
0.708	94.2	94.5	94.7	94.9	95.1	95.4	95.6	95.8	96.0	96.3	96.5	96.7	96.9	97.2	97.4	97.6	97.8	98.0	98.3	98.5	98.7
0.709	93.9	94.2	94.4	94.6	94.8	95.1	95.3	95.5	95.7	96.0	96.2	96.4	96.6	96.9	97.1	97.3	97.5	97.7	98.0	98.2	98.4
0.710	93.6	93.9	94.1	94.3	94.5	94.8	95.0	95.2	95.4	95.7	95.9	96.1	96.3	96.6	96.8	97.0	97.2	97.4	97.7	97.9	98.1
0.711	93.3	93.6	93.8	94.0	94.2	94.5	94.7	94.9	95.1	95.4	95.6	95.8	96.0	96.3	96.5	96.7	96.9	97.1	97.4	97.6	97.8
0.712	93.0	93.3	93.5	93.7	93.9	94.2	94.4	94.6	94.8	95.1	95.3	95.5	95.7	96.0	96.2	96.4	96.6	96.8	97.1	97.3	97.5
0.713	92.7	93.0	93.2	93.4	93.6	93.9	94.1	94.3	94.5	94.8	95.0	95.2	95.4	95.7	95.9	96.1	96.3	96.5	96.8	97.0	97.2
0.714	92.4	92.7	92.9	93.1	93.3	93.6	93.8	94.0	94.2	94.5	94.7	94.9	95.1	95.4	95.6	95.8	96.0	96.2	96.5	96.7	96.9
0.715	92.1	92.4	92.6	92.8	93.0	93.3	93.5	93.7	93.9	94.2	94.4	94.6	94.8	95.1	95.3	95.5	95.7	95.9	96.2	96.4	96.6

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[1] Prepared by Prof. E. R. Hulbirt.

[2] Woglum, R. S. A dosage schedule for citrus fumigation with liquid hydrocyanic acid. *In* Journ. Econ. Ent., v. 12, no. 5, p. 357–363, 1919.

TABLE 5.—*Table for calculating the amount of liquid hydrocyanic acid (97 per cent), in pounds, required to fumigate different numbers of 2 to 60 charge trees with 16, 18, or 20-cubic-centimeter units (88, 100, or 111 per cent schedules).*

Charges per tree.	Number of trees.																																
	10			15			20			25			30			35			40			45			50			60			70		
	Dosage schedule and size of unit charge.																																
	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %	88 %	100 %	111 %
	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.	16 c. c.	18 c. c.	20 c. c.
	Pounds of liquid hydrocyanic acid required.																																
2	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	1.5	2.0	2.0	2.0	2.0	2.5	2.0	2.5	2.5	2.5	3.0	3.0	2.5	3.0	3.5	3.0	3.5	4.0	3.5	4.0	4.5
4	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.5	3.0	3.5	4.0	3.5	4.0	4.5	4.0	4.5	5.0	4.5	5.5	6.0	5.0	6.0	6.5	6.0	7.0	7.5	7.0	8.0	9.0
6	1.5	2.0	2.0	2.5	3.0	3.0	3.0	3.5	4.0	4.0	4.5	5.0	4.5	5.5	6.0	5.5	6.0	7.0	6.0	7.0	7.5	7.0	8.0	8.5	7.5	8.5	9.5	9.0	10.5	11.5	10.5	12.0	13.5
8	2.0	2.5	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.0	6.0	6.5	6.0	7.0	7.5	7.0	8.0	9.0	8.0	9.0	10.0	9.0	10.5	11.5	10.0	11.5	12.5	12.0	13.5	15.0	14.0	16.0	17.5
10	2.5	3.0	3.5	4.0	4.5	5.0	5.0	6.0	6.5	6.5	7.0	8.0	7.5	8.5	9.5	9.0	10.0	11.0	10.0	11.5	12.5	11.5	13.0	14.0	12.5	14.0	16.0	15.0	17.0	19.0	17.5	20.0	22.0
12	3.0	3.5	4.0	4.5	5.5	6.0	6.0	7.0	7.5	7.5	8.5	9.5	9.0	10.5	11.5	10.5	12.0	13.0	12.0	13.5	15.0	13.5	15.5	17.0	15.0	17.0	19.0	18.0	20.5	22.5	21.0	24.0	26.5
14	3.5	4.0	4.5	5.5	6.0	7.0	7.0	8.0	9.0	9.0	10.0	11.0	10.5	12.0	13.5	12.5	14.0	15.5	14.0	16.0	17.5	16.0	18.0	20.0	17.5	20.0	22.0	21.0	24.0	26.5	24.5	27.5	30.5
16	4.0	4.5	5.0	6.0	7.0	7.5	8.0	9.0	10.0	10.0	11.5	12.5	12.0	13.5	15.0	14.0	16.0	17.5	16.0	18.0	20.0	18.0	20.5	22.5	20.0	22.5	25.0	24.0	27.0	30.0	28.0	31.5	35.0
18	4.5	5.5	6.0	7.0	8.0	8.5	9.0	10.5	11.5	11.5	13.0	14.0	13.5	15.5	17.0	16.0	18.0	20.0	18.0	20.5	22.5	20.5	23.0	25.5	22.5	25.5	28.0	27.0	30.5	34.0	31.5	35.5	39.5
20	5.0	6.0	6.5	7.5	8.5	9.5	10.0	11.5	12.5	12.5	14.0	16.0	15.0	17.0	19.0	17.5	20.0	22.0	20.0	22.5	25.0	22.5	25.5	28.0	25.0	28.0	31.5	30.0	34.0	37.5	35.0	39.5	44.0
22	5.5	6.5	7.0	8.5	9.5	10.5	11.0	12.5	14.0	14.0	15.5	17.5	16.5	18.5	21.0	19.5	22.0	24.0	22.0	25.0	27.5	25.0	28.0	31.0	27.5	31.0	34.5	33.0	37.0	41.0	38.5	43.5	48.0
24	6.0	7.0	7.5	9.0	10.5	11.5	12.0	13.5	15.0	15.0	17.0	19.0	18.0	20.5	22.5	21.0	24.0	26.5	24.0	27.0	30.0	27.0	30.5	34.0	30.0	34.0	37.5	36.0	40.5	45.0	42.0	47.5	52.5
26	6.5	7.5	8.5	10.0	11.0	12.5	13.0	15.0	16.5	16.5	18.5	20.5	19.5	22.0	24.5	23.0	25.5	28.5	26.0	29.5	32.5	29.5	33.0	36.5	32.5	36.5	40.5	39.0	44.0	48.5	45.5	51.0	57.0
28	7.0	8.0	9.0	10.5	12.0	13.5	14.0	16.0	17.5	17.5	20.0	22.0	21.0	24.0	26.5	24.5	27.5	30.5	28.0	31.5	35.0	31.5	35.5	39.5	35.0	39.5	43.5	42.0	47.5	52.5	49.0	55.0	61.0
30	7.5	8.5	9.5	11.5	13.0	14.0	15.0	17.0	19.0	19.0	21.0	23.5	22.5	25.5	28.0	26.5	29.5	33.0	30.0	34.0	37.5	34.0	38.0	42.0	37.5	42.0	47.0	45.0	50.5	56.0	52.5	59.0	65.5
32	8.0	9.0	10.0	12.0	13.5	15.0	16.0	18.0	20.0	20.0	22.5	25.0	24.0	27.0	30.0	28.0	31.5	35.0	32.0	36.0	40.0	36.0	40.5	45.0	40.0	45.0	50.0	48.0	54.0	60.0	56.0	63.0	70.0
34	8.5	10.0	11.0	13.0	14.5	16.0	17.0	19.5	21.5	21.5	24.0	26.5	25.5	29.0	32.0	30.0	33.5	37.5	34.0	38.5	42.5	38.5	43.0	48.0	42.5	48.0	53.0	51.0	57.5	63.5	59.5	67.0	74.5
36	9.0	10.5	11.5	13.5	15.5	17.0	18.0	20.5	22.5	22.5	25.5	28.0	27.0	30.5	34.0	31.5	35.5	39.5	36.0	40.5	45.0	40.5	45.5	50.5	45.0	50.5	56.0	54.0	60.5	67.5	63.0	71.0	78.5
38	9.5	11.0	12.0	14.5	16.0	18.0	19.0	21.5	24.0	24.0	27.0	30.0	28.5	32.0	35.5	33.5	37.5	41.5	38.0	43.0	47.5	43.0	48.0	53.5	47.5	53.5	59.5	57.0	64.0	71.0	66.5	74.5	83.0
40	10.0	11.5	12.5	15.0	17.0	19.0	20.0	22.5	25.0	25.0	28.0	31.5	30.0	34.0	37.5	35.0	39.5	44.0	40.0	45.0	50.0	45.0	50.5	56.0	50.0	56.0	62.5	60.0	67.5	75.0	70.0	78.5	87.5
50	12.5	14.0	16.0	19.0	21.0	23.5	25.0	28.0	31.5	31.5	35.0	39.0	37.5	42.0	47.0	44.0	49.0	54.5	50.0	56.0	62.5	56.5	63.0	70.0	62.5	70.0	78.0	75.0	84.0	93.5	87.5	98.0	109.0
60	15.0	17.0	19.0	22.5	25.5	28.0	30.0	34.0	37.5	37.5	42.0	47.0	45.0	50.5	56.0	52.5	59.0	65.5	60.0	67.5	75.0	67.5	76.0	84.0	75.0	84.0	93.5	90.0	101.0	112.0	105.0	118.0	131.0

DOSAGE SCHEDULES.[12]

The term "dosage" is used to indicate the amount of cyanid needed to destroy a particular insect, and varies with the size of the tree. Since a definite amount of gas is generated from an ounce of cyanid, the ounce has been established as the unit of dosage for the pot and fumigating machine. In the case of the latter the cyanid is in solution, but the measuring pump is so graduated that each unit represents 1 ounce of solid sodium cyanid.

Several years of experimental work in California, during which thousands of trees have been treated for the control of different scale insects, have made it possible to calculate dosages for different-sized trees and to prepare tables in convenient form for rapid use in the field. These dosages are based on actual results under practical field conditions, proper consideration being given to the important subject of leakage.

DISTANCE AROUND IN FEET

DISTANCE OVER IN FEET

	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
10	2	2	3	3	3															10																10
12	3	3	3	4	4	4	4													12																12
14	3	3	4	4	4	4	5	5												14																14
16	4	4	4	4	5	5	5	5	5	5	5	6								16																16
18	4	4	4	5	5	5	5	5	6	6	6	6	6							18																18
20			4	5	5	5	6	6	6	6	7	7	7	7	7	7	7			20																20
22					5	6	6	6	7	7	7	7	7	8	8	8	8	8		22																22
24					6	6	6	7	7	7	7	8	8	8	8	8	9	9	9	24																24
26								7	7	8	8	8	8	9	9	9	9	9	10	26	10															26
28									8	8	8	9	9	9	9	10	10	10	10	28	11	11	11													28
	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
30										8	9	9	9	10	10	10	11	11	11	30	12	12	12	12	13	13										30
32											9	9	10	10	11	11	12	12	12	32	13	13	13	14	14	14	15									32
34												10	10	11	12	12	13	13	13	34	14	14	14	15	15	15	16	16								34
36												10	11	12	12	13	13	14	14	36	15	15	16	16	16	16	17	17								36
38													12	12	13	14	14	15	15	38	16	16	17	17	17	18	18	18	19							38
40																14	15	16	16	40	17	17	18	18	18	19	19	19	20	20	21					40
42																	16	17	17	42	18	18	19	19	20	20	20	21	21	22	22	22				42
44																		17	18	44	19	19	20	20	21	21	21	22	22	22	23	23	24			44
46																				46	20	20	21	21	22	22	23	23	23	24	24	24	25	25	26	46
48																				48	20	21	22	22	23	23	24	24	25	25	25	26	26	27	27	48
	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
50																				50	21	22	23	23	24	24	25	25	26	26	27	27	28	28	29	50
52																				52				24	25	25	26	26	27	27	28	28	29	30	30	52
54																				54					25	26	27	28	28	29	29	30	31	31	32	54
56																				56						27	28	28	29	30	31	31	32	33	33	56
58																				58						28	28	29	30	31	32	33	33	34	34	58

FIG. 18.—Dosage Schedule No. 1 (100 per cent), for pot or fumigating machine, for sodium cyanid 96–99 per cent (containing not less than 51.3 per cent cyanogen). Dosages are in ounces. (Revised form.)

One table prepared by this department has formed the basis for fumigation dosage in California since 1908. Fumigators, however, have felt that the dosages for small trees as given on this schedule were a little too low, and in recent years this has led to the practice of slightly increasing the dosages for trees of this size. The old schedule has therefore been revised and the revised form is shown in Figure 18.

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[12] In previous writings the author has referred to high-grade sodium cyanid as being 126 to 130 per cent pure. An equal amount by weight of chemically pure sodium cyanid liberates 33 per cent more hydrocyanic-acid gas than does pure potassium cyanid; and as potassium cyanid was the chemical formerly used for generating hydrocyanic-acid gas, this was expressed by designating the pure sodium cyanid as 133 per cent. In this bulletin where sodium cyanid is mentioned as 96 to 99 per cent pure, or containing not less than 51 per cent of cyanogen, it is of the same strength as that termed in former writings "126 to 130 per cent pure." Likewise Dosage Schedule 1 for sodium cyanid 96 to 99 per cent pure, containing not less than 51 per cent of cyanogen, is the same schedule as that formerly termed "Dosage Schedule 1" for sodium cyanid 126 to 130 per cent pure.

The dosage for a tree is determined by two measurements taken after the tree is covered with a tent. These are the distance in feet around the tent at a height of about 3 feet from the ground and the distance in feet over the top of the tent from ground to ground. The numbers indicating the size of the tree are arranged along the outer sides of the chart. The square in the chart, formed by the intersection of the lines running from the two numbers representing, respectively, the distance around and the distance over a tree, contains the dosage for a tree of this size. For example, if it is found that the distance over the tent is 30 feet and the distance around the tent is 42 feet, the intersection of the lines leading from these numbers indicates that 10 ounces of sodium cyanid is the amount required by a tree of that size with Dosage Schedule No. 1. (See Fig. 18.) Using the 1–1½–2 formula for sodium cyanid in pot generation, 15 ounces of sulphuric acid and 20 ounces of water would be required for this charge. For the fumigating machine the plunger is raised to 10 and then lowered in order to discharge the proper amount of solution.

Dosage Schedule No. 1, sometimes called the 100 per cent or full schedule, gives a somewhat concentrated gas—a gas stronger than every condition demands. To meet this demand for lighter dosage a schedule of dosages three-fourths or 75 per cent as strong as Schedule No. 1 may be used. Some fumigators use an 85 per cent dosage schedule calculated from Schedule No. 1; others use schedules giving a more concentrated gas, as 110, 125, or even 150 per cent.

The introduction of liquid gas led to a partial revision in dosage procedure and the establishment of a new unit of measurement. Investigations of this department[13] developed that under field conditions 18 cubic centimeters of high-grade liquid hydrocyanic acid (95 to 98 per cent) produced results in scale kill equivalent to those of 1 ounce of high-grade sodium cyanid. Accordingly, 18 cubic centimeters was adopted as the unit of measurement for liquid hydrocyanic acid.[14] The dosage schedule for solid sodium cyanid was followed in the first fumigation with liquid gas, but it was soon found that a revision was needed, to give increased dosages for large, tall trees. Accordingly, a schedule specially revised for liquid gas was prepared (Fig. 19 and Table 6), and this schedule has been successfully followed for two seasons in liquid-gas fumigation in California. Each unit of dosage in this schedule is based on a delivery of 18 cubic centimeters of liquid hydrocyanic acid, 95 to 98 per cent pure, in the form of a very fine spray beneath the tented tree. Thus a tree 30 feet over by 40 feet around calls for 11 charges of 18 cubic centimeters (198 cubic centimeters). By graduating the applicator used in generating the gas in numbers corresponding to those on the schedule, and providing that each graduation delivers a charge equal to the number of cubic centimeters of which itself and 18 are the product, this schedule is made equally as practical as former schedules. This schedule has given results equivalent to Schedule 1 for sodium cyanid, and should be substituted for Schedule 1 wherever formerly employed in pot or machine generation.

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[13] Woglum, R. S. A dosage schedule for citrus fumigation with liquid hydrocyanic acid. *In* Journ. Econ. Ent., v. 12, no. 5, p. 357–363, 1919.

[14] Quayle (Univ. Calif. Agr. Expt. Sta. Bul. 308, p. 407) recommends 20 cubic centimeters as the equivalent of 1 ounce of sodium cyanid.

DISTANCE AROUND IN FEET

DISTANCE OVER IN FEET

	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
10	2	2	3	3	3															10																10
12	3	3	3	4	4	4	4													12																12
14	3	3	4	4	4	4	5	5												14																14
16	4	4	4	4	5	5	5	5	5	5										16																16
18	4	4	4	5	5	5	5	5	6	6	6	6	6							18																18
					20	22	24	28	28	30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
20					5	5	6	6	6	6	6	7	7	7	7	7				20																20
22					5	6	6	6	6	7	7	7	7	7	7	7	8	8		22																22
24					6	6	6	6	7	7	7	7	8	8	8	8	9	9		24																24
26								7	7	7	7	8	8	9	9	9	10	10	10	26	11															26
28									7	7	8	8	9	9	10	10	11	11	11	28	12															28
										30	32	34	36	38	40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
30										8	8	9	10	10	11	11	12	12	12	30	13	13	14	14	14											30
32											9	10	10	11	12	12	13	13	14	32	14	15	15	15	16	16										32
34												10	11	12	13	13	14	14	15	34	15	16	17	17	17	18	18	18								34
36												11	12	13	14	14	15	15	16	36	17	17	18	18	19	19	20	20	21							36
38													13	14	14	15	16	17	17	38	18	18	19	20	20	21	21	22	22							38
															40	42	44	46	48		50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
40																16	17	18	18	40	19	20	21	21	22	22	23	24	24	25	25					40
42																	18	19	20	42	21	21	22	23	23	24	25	25	26	26	27	28				42
44																		20	21	44	22	23	23	24	25	26	27	27	28	28	29	30	30			44
46																				46	23	24	25	26	27	27	28	29	29	30	31	32	32	33		46
48																				48	24	25	26	27	28	29	30	31	31	32	33	34	34	35	36	48
																					50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	
50																				50	25	26	27	28	30	30	31	32	33	34	35	36	36	37	38	50
52																				52				30	31	32	33	34	35	36	37	38	38	39	40	52
54																				54					32	33	35	36	37	38	39	40	40	41	42	54
56																				56						35	36	38	39	40	41	42	42	43	44	56
58																				58						36	38	39	40	41	42	43	44	45	47	58

100% DOSAGE UNIT=18 CUBIC CENTIMETERS

FIG. 19.—A dosage schedule for citrus-tree fumigation with liquid hydrocyanic acid 95 to 98 per cent pure.

TABLE 6.—*Dosage schedule for citrus-tree fumigation with liquid hydrocyanic acid—same dosages as given in Figure 19, but in special arrangement for copying directly on fumigation tapes.*

[Top figures represent distance around. The italic figures under each "distance around" represent distances over trees and the roman figures contain the dosages.]

12	14	16	18	20	22	24	26	28	30	32	34
10—2 *12*—3 *14*—3 *16*—4 *18*—4	*10*—2 *12*—3 *14*—3 *16*—4 *18*—4	*10*—3 *12*—3 *14*—4 *16*—4 *18*—4	*10*—3 *12*—4 *14*—4 *16*—4 *18*—5	*10*—3 *12*—4 *14*—4 *16*—5 *18*—5 *20*—5 *22*—5 *24*—6	*12*—4 *14*—4 *16*—5 *18*—5 *20*—5 *22*—6 *24*—6	*12*—4 *14*—5 *16*—5 *18*—5 *20*—6 *22*—6 *24*—6	*14*—5 *16*—5 *18*—5 *20*—6 *22*—6 *24*—6 *26*—7	*16*—5 *18*—6 *20*—6 *22*—6 *24*—7 *26*—7 *28*—7	*16*—5 *18*—6 *20*—6 *22*—7 *24*—7 *26*—7 *28*—7 *30*—8	*18*—6 *20*—6 *22*—7 *24*—7 *26*—7 *28*—8 *30*—8 *32*—9	*18*— 6 *20*— 7 *22*— 7 *24*— 7 *26*— 8 *28*— 8 *30*— 9 *32*—10 *34*—10 *36*—11

TABLE 6.—*Dosage schedule for citrus-tree fumigation, with liquid hydrocyanic acid*—Continued.

36	38	40	42	44	46	48	50	52	54	56
18—6	20—7	20—7	20—7	22—8	22—8	26—10	26—11	30—13	30—14	30—14
20—7	22—7	22—7	22—7	24—9	24—9	28—11	28—12	32—15	32—15	32—15
22—7	24—8	24—8	24—8	26—10	26—10	30—12	30—13	34—16	34—17	34—17
24—8	26—9	26—9	26—9	28—11	28—11	32—14	32—14	36—17	36—18	36—18
26—8	28—9	28—10	28—10	30—12	30—12	34—15	34—15	38—18	38—19	38—20
28—9	30—10	30—11	30—11	32—13	32—13	35—16	36—17	40—20	40—21	40—21
30—10	32—11	32—12	32—12	34—14	34—14	38—17	38—18	42—21	42—22	42—23
32—10	34—12	34—13	34—13	36—15	36—15	40—18	40—19	44—23	44—23	44—24
34—11	35—13	35—14	35—14	38—16	38—17	42—20	42—21	46—24	46—25	46—26
36—12	38—14	38—14	38—15	40—17	40—18	44—21	44—22	48—25	48—26	48—27
38—13			40—16	42—18	42—19		46—23	50—26	50—27	50—28
					44—20		48—24			52—30
							50—25			

58	60	62	64	66	68	70	72	74	76	78
30—14	32—16	34—18	34—18	36—21	40—25	40—25	42—28	44—30	46—33	48—36
32—16	34—18	36—20	36—20	38—22	42—26	42—27	44—30	46—32	48—35	50—38
34—17	35—19	38—21	38—22	40—24	44—28	44—29	46—32	48—34	50—37	52—40
36—19	38—21	40—23	40—24	42—26	46—30	46—31	48—34	50—36	52—39	54—42
38—20	40—22	42—25	42—25	44—28	48—32	48—33	50—36	52—38	54—41	56—44
40—22	42—24	44—27	44—27	46—29	50—34	50—35	52—38	54—40	56—43	58—47
42—23	44—26	46—28	46—29	48—31	52—36	52—37	54—40	56—42	58—45	
44—25	46—27	48—30	48—31	50—33	54—38	54—39	56—42	58—44		
46—27	48—29	50—31	50—32	52—35	56—40	56—41	58—43			
48—28	50—30	52—33	52—34	54—37	58—41	58—42				
50—30	52—32	54—35	54—36	56—39						
52—31	54—33	56—36	56—38	58—40						
54—32	56—35	58—38	58—39							
	58—36									

The first applicators for liquid gas had fixed dosage plates. Subsequently the writer's suggestion of detachable dosage plates,[15] each to correspond to a special schedule, was adopted, and all applicators now are equipped with a set of plates the graduations on which represent 14, 16, 18, 20, and 22 cubic centimeter units, or 77, 88, 100, 111, and 122 per cent schedules.

FUMIGATION PROCEDURE.

HOW TO MEASURE THE TREES.

As was stated in the preceding section, the dosage for a tented tree is based on the distance over the top and the distance around the bottom. The distance over the top of a tree is measured easily with a tapeline, but a much better and quicker method is to mark the tent as described previously. When such a marked tent is centered over a tree, the distance over the top is obtained by adding the two numbers that show where the line over the top of the tree touches the ground on opposite sides.

In tenting trees, especially small ones, the center of the tent frequently will fall to one side of the center of the tree, and in such instances one of the auxiliary lines is used. To avoid confusion, the center line should be heavier than the other two. The distance around the tent is taken by means of a tapeline, and can be measured by one man if the tape be provided with a catch for attachment to the tent. This measurement should be taken about 3 feet above the ground. **Never guess the distance around by pacing.**

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[15] Woglum, R. S. Practical fumigation with liquid hydrocyanic acid. *In* Calif. Citrograph, v. 4, no. 10, p. 284, 1919.

SPECIAL SCHEDULE TAPES.

In 1920 a special tape was developed on which dosages were stamped at 2-foot intervals. An example of this marking is shown in Figure 20. The distance around the tree is indicated by the large numerals. The column of figures at the left indicates distances over the top and that at the right indicates dosage. These tapes were widely used in California in 1921. They do away with schedule cards, expedite dosage calculation, and tend toward greater accuracy. If the tape is marked on both sides, but with the numbering starting from opposite ends, the ends can be alternated as one tree after another is measured. Dosage tapes can be made for either cyanid or liquid gas schedules. A schedule of liquid gas dosages in form for copying on tapes is shown in Table 6.

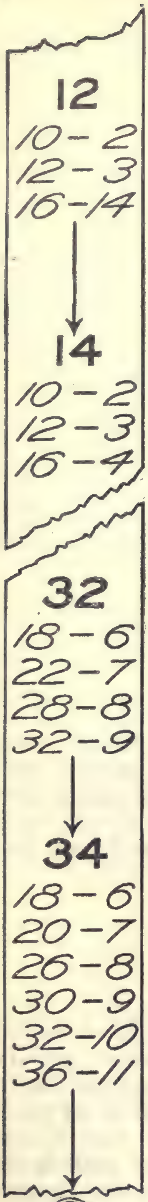


FIG. 20.—Showing method of marking the dosage on a fumigation tape. Large numbers represent distance around in feet; left-hand column represents distance over the tree; right-hand column, the dosage. (Liquid-gas schedule.)

HOW TO COVER THE TREES.

Commercial fumigators usually require that the soil in the orchard shall have been cultivated recently, so that it will be loose and level before the work of fumigation is begun, thus permitting the tents to lie smooth and close to the ground. One tent is then spread on the ground on the side of each tree, in the first row to be treated, farthest from the center of the orchard.

For covering trees up to 18 or 20 feet in height, two poles of the character described on page 5 are required, one for each side of the tree. Preferably, the poles should be about a foot longer than the height of the trees. If rings are attached to the tents the ends of the poles are inserted into the rings. Some fumigators do not use rings on tents manipulated by poles, but double lap the edge of the tent over the end of the pole and attach it by a half hitch of the pulling rope (Fig. 21). This is done quickly, does not subject the tent to undue wear, prevents detachment, which sometimes occurs with rings, and allows

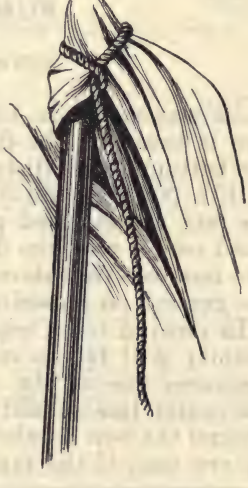
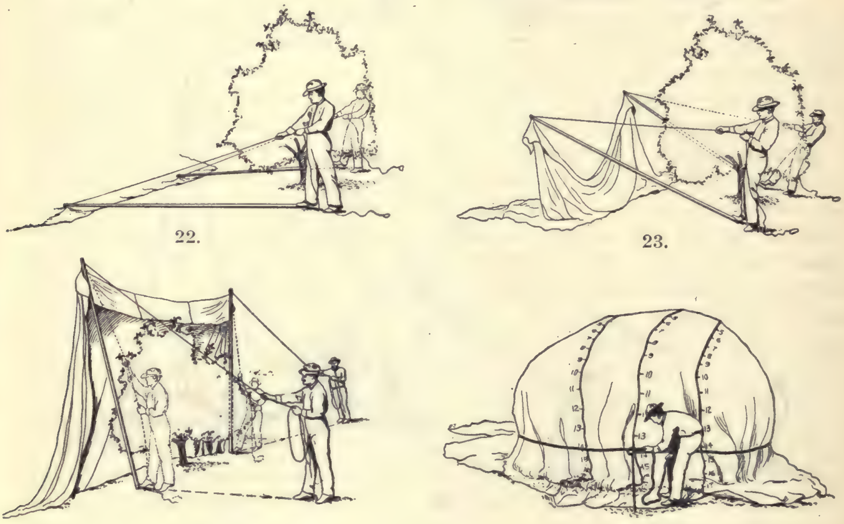


FIG. 21.—Method of attaching tent to hoisting pole by a half hitch of the rope.

the distance between the poles to be varied in accordance with the width of the tree. To prevent the seams from pulling apart, the tent always should be moved in the direction in which the strips run.

The successive stages in covering a tree are shown in Figures 22 to 25. The tent should be held taut between the ends of the poles to prevent it from catching in the top of the tree by sagging. When the covering is completed the poles are detached and carried to the next tree to be covered.

Great care should be exercised in covering large trees to avoid overpulling the tent. The bottom of the tent should be kicked in and, at the same time, examined to see that it lies close to the ground the entire distance around the tree. Where possible, it is much easier to transfer a tent from tree to tree without pulling it to the ground. The poles should be attached to the edge of the tent, then raised and leaned against the tented tree. The remaining steps are the same as those previously explained.

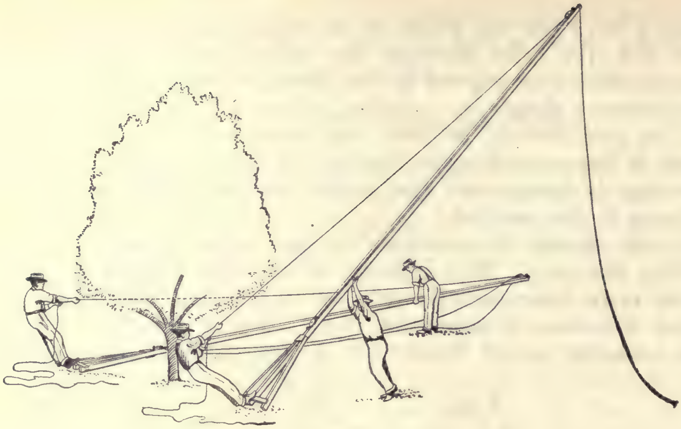

22. 23. 24. 25.

FIGS. 22–25.—Successive stages in placing a tent over a tree with poles.

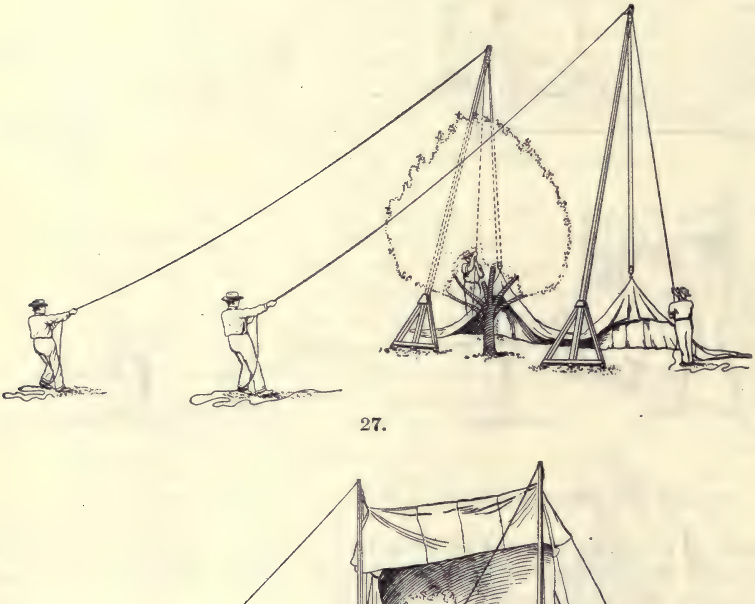
To cover very large trees derricks similar to that shown in Figure 3 should be used. Four men are required for their manipulation. (See Figs. 26 to 28.)

OPERATION OF AN OUTFIT.

The number of men required to operate a fumigation outfit depends upon the size and number of tents. Two men will handle a large string of 30-foot tents on small trees coverable without poles, although some managers prefer three men for the same work. Large strings of 36 to 43 foot tents require a four-man crew—two pullers, a foreman, and a generator. Outfits of 45-foot tents and upward are usually operated by six men, including four pullers. These figures apply to liquid gas and fumigating machine crews; under the pot system an additional man is required for generating (Fig. 11).



26.



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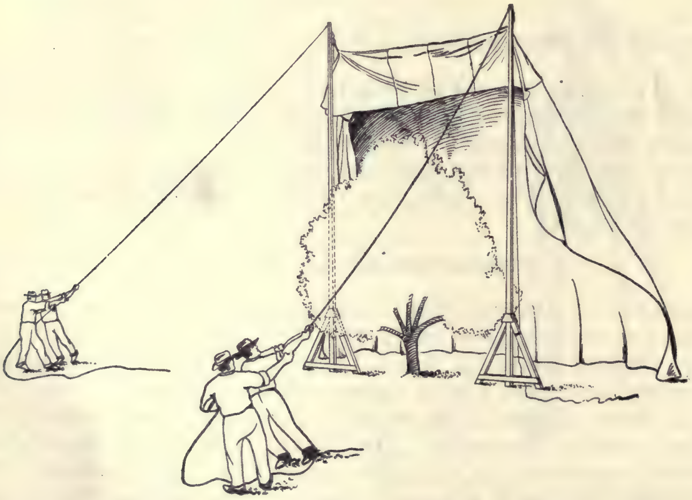

28.

FIGS. 26–28.—Successive stages in placing a tent over a tree by means of derricks.

For many years 30 tents were considered the proper number for an outfit, and two pullers moved the tents. In recent years, with higher labor costs and constantly increasing acreage to be fumigated, the tendency has been to put on four pullers, speed up the work, and increase the number of tents to the limit movable within a one-hour exposure. The average outfit is 45 to 70 tents, but as many as 80 to 90 tents have been manipulated by one six-man crew under ideal weather and orchard conditions.

Each outfit has a foreman, whose duties include supervision of preparation for the night's work and proper direction of the actual field operations. The foreman should be a careful, experienced fumigator. Some managers have the foreman act as generator, but preferably he should be the tape man, a position from which he can closely watch both the pullers and generator.

The first step in fumigation procedure is to cover the trees, and this is closely followed by calculation and application of the dosage. The careful foreman will keep the pullers two to three trees ahead of the generator throughout the row, and the progress should be consistent rather than irregular. The tendency of pullers to hasten toward the end of a row shortens the exposure and should not be permitted. At the finish of a row the crew returns to the commissary and preparations are made for the next row. When using the fumigating machine the residue is emptied outside the grove before refilling. With the pots care must be taken to place them well in toward the trunk, so that any spattering of acid during the generation of gas will not reach the cloth. The man handling the acid should never touch the tents. The residue should always be emptied away from the tree trunks and distant from the tents. The capacity of the fumigating machine or liquid-gas applicator is sometimes inadequate for the entire row and thus requires a refill before the finish. In such cases an auxiliary supply of cyanid solution or liquid gas should be placed toward the middle of the row. A record should be kept of the time each row is fumigated, of the temperature, humidity, wind, sunshine, and the dosage for each tree. The type of chart in common use for this purpose is shown in Figure 29.

Hour started.	Temp. W. S.	Hum. tent damp.	Row.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			1																				
			2																				
			3																				
			4																				
			5																				

Fig. 29.—Field chart for recording the dosage given each tree and the weather conditions, temperature, humidity, sunshine (s), wind (w), and whether or not tents are damp. On opposite side of chart should be noted the orchard, date, dosage schedule, system of fumigation, insect, amount of material used, number of trees, direction tents are moved and foreman.

CARE OF TENTS.

Tents often become wet at night, particularly late in the season. Wet tents should be avoided in fumigating. Then, too, long-continued dampness tends to weaken the fabric. Wet tents should be spread out on the ground after the last throw. If the trees are large and closely set it might be well for a day man to go over the tents to spread out the folds. After rains tents should be turned until dried. Tents should never be left without attention throughout long-continued rainy periods, but should frequently be moved to prevent mildew. The best way to dry out very wet tents is to draw them halfway over trees. This practice can not be recommended during very hot weather but is of common occurrence in California during the cooler season.

TIME CARD.

Foreman.............................. Date..............................
Grove.............................. Amt. material..............................
Trees.............................. Method..............................
Size tents.............................. Throws..............................

NAME.	OPERATION.	HOURS—TREES.	CASH.

FIG. 30.—A daily time card to record the work of each fumigation crew.

One of the greatest necessities, and at the same time the one most likely to escape notice, is the proper repairing of fumigation tents. If acid comes in contact with a tent, a hole is certain to be the result, and even with very careful operators acid holes are occurring constantly. These become very numerous if not attended to, and permit leakage of gas. Moreover, tears in tents are of frequent occurrence.

Every large outfit should employ a man to overhaul tents and keep them in the best possible state of repair. This man should be supplied with a sewing machine adapted to tent mending. Tents are best patched by sewing pieces of canvas over the holes, rather than by trying to draw holes together with threads. Patches stuck by rubber tissue are temporarily satisfactory, but are not lasting, and for this reason are inferior to those machine-sewed. Some fumigators mend tents in the field, while others send them to the warehouse for repairs. When tents are new they probably are most economically repaired at the warehouse, but when old and needing overhauling every few days the repair man should have his sewing machine in the field. Pullers should be constantly on the watch for tears, and when detected the condition and tent number can be noted on the daily report of the foreman (Fig. 30). All tents should be numbered. At the close of the season tents should be thoroughly dried, carefully gone over, and repaired, rolled, and then stored in a closed building having a floor elevated above the ground (Fig. 31). When the centers of tents are worn out before the skirts, or vice versa, it is not necessary to discard the entire tent, but the cloth of good quality can be made into tents of smaller sizes.

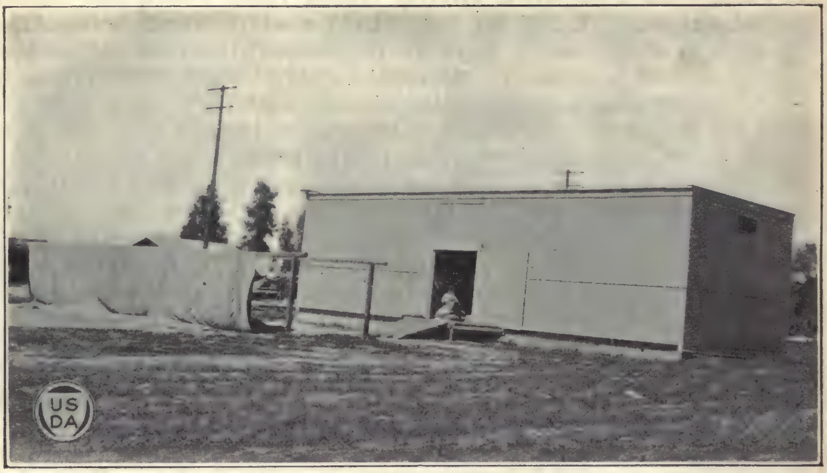

FIG. 31.—Standards for spreading tents to be examined in process of overhauling. The building is used for storing tents.

NECESSITY FOR CAREFUL WORKERS.

Unsatisfactory fumigation is frequently the direct result of carelessness, and for fumigating an orchard it is of primary importance to have careful, conscientious men. It is very easy for a careless scheduler to form the habit of guessing the dosage rather than measuring the trees, for the careless man with the supply wagon to make mistakes in weighing the chemicals, for the generator to go through the motion of dosing the last few trees in a row although the supply of chemicals in the machine is exhausted, or not to trouble himself with testing the applicator although apparently out of order, and for the tent pullers not to kick in the skirts of the tents or pull down the sides which do not touch the ground. The reliable foreman will aim toward effective fumigation and give the fullest attention to details. Furthermore, he will not condone negligence in the other members of the crew. The foreman is really the keystone or pivot man in high-class work. Every effort should be made to employ experienced, reliable men and to retain such foremen from year to year. Unfortunately, a large number of dependable men are lost every year, owing doubtless in large part to the short season and method of employment. Employment on a monthly salary might well supplant the customary tree or hour basis, and an attempt should be made to retain foremen in some permanent position outside the fumigation season. In recent years there has been a strong tendency for growers to organize into cooperative fumigation associations and employ a competent, well-trained man at a regular salary to take charge of all their pest-control activities.

GENERAL CAUTIONS.

Hydrocyanic-acid gas is one of the most deadly gases known. Therefore precautions in its use are essential. The careful fumigator who avoids being subjected to strong fumes, however, runs no risk. In California men work around tented trees where they breathe diluted gas every night for several consecutive weeks without feeling any ill effects aside from an occasional dizziness or headache. Cyanid should be kept in containers tightly locked while not in use.

Hydrocyanic-acid gas is inflammable, and care should be exercised not to permit the concentrated gas as it rises from the generator to come in contact with fire; diluted gas is not inflammable.

Liquid hydrocyanic acid is far more dangerous than solid cyanid or cyanid solution. Several fatalities have occurred since the introduction of liquid gas and a noticeable increase in the number of cases of people temporarily overcome. The liquid is most active at high temperatures and should always be stored under cool conditions, and in the field protected from the sunshine. The greatest care is necessary in opening a drum, especially when the gas is boiling and pressure has developed. When suddenly uncapped the liquid might spout upward. A safety valve on every drum would reduce the present hazard. It is advisable for two men to be present when a drum of gas is handled or an applicator filled. The tape man should always keep a watchful eye on the generator. A small bottle of ammonia should be in the pocket of every fumigator. When a man is overcome, place ammonia at the nostrils and encourage respiration by the prone pressure method of resuscitation.[16] Never use exposed flames near liquid gas. For close-up work about drums or the applicator an electric flash is safe and convenient.

BOX TENTS.

Gas-tight boxes have come into use in California for small trees and several such outfits have carried on fumigation in districts where small trees are most numerous. The dosage required for these gas-tight boxes is less than half that needed for canvas tents, but the manipulation of the boxes is decidedly more laborious than that of the ordinary covers. The type of box shown in Figure 32 has proved most popular. It is built in sections and is collapsible.

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[16] Anybody not familiar with the prone pressure method of resuscitation should apply to the Bureau of Mines, Department of the Interior, Washington, D. C., for a circular which illustrates and describes this method.

The number of sections is increased or decreased as necessitated by the size of the trees to be fumigated. The results in scale kill appear to be more uniform than with common tents.

EFFECT OF THE GAS ON THE PLANT.[17]

Hydrocyanic-acid gas is fatal to insects when the dose is sufficiently large and the exposure long enough, but a much greater strength of gas is necessary for the destruction of some insects than for others. Were it not for the destructive action of the gas on the plants, its field of usefulness would be increased greatly. Since different species and varieties of plants vary remarkably in their power to withstand the poison, however, it is necessary in fumigating with this gas to take into consideration the particular plants to be fumigated and their susceptibility to gas injury.

The foliage and branches of orange, lemon, and grapefruit trees will stand without severe injury a strength of gas sufficient to destroy most of the scale insects which infest them. Apple, peach, pear, and other deciduous trees in dormant condition can be fumigated without injury with a strength of gas greater than it would be advisable to use on citrus fruit trees.

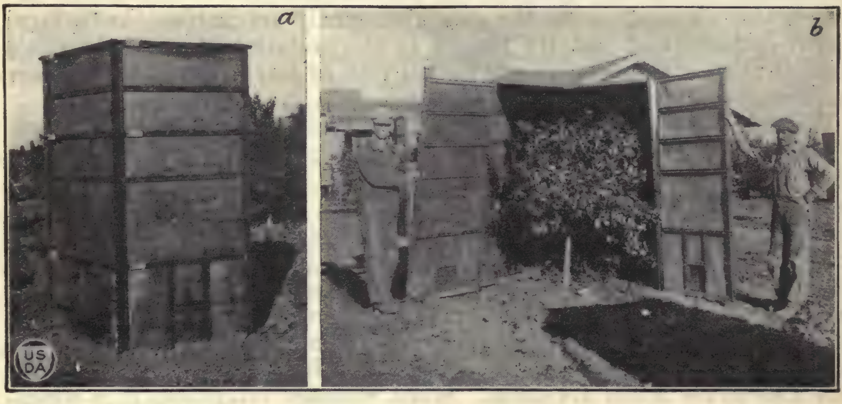

FIG. 32.—A gas-tight box tent for covering small trees. Constructed in sections to make 3, 4, or 5-sided boxes. *a*, Closed; *b*, opened.

It is impossible to fumigate a citrus tree effectively without burning back for a few inches many of the tenderest shoots. Slight burning of the foliage, however, is not considered injurious to the trees. The injury to be avoided is the burning and pitting of fruit, and this frequently occurs unless great care is exercised.

The action of hydrocyanic-acid gas on the plant cells is the cause of fruit burning as well as foliage injury in fumigation. Numerous factors, explained later, serve to intensify the injury, but these factors are distinct from the main cause.

The tenderest shoots of plants are the ones most easily injured by this gas. It is well known that a very heavy dosage in field fumigation will not only pit full-grown fruit but even destroy the old resistant foliage. Plants in dormant condition are more resistant to gas than are those in their period of growth. When fruit is small and tender it is easily pitted by a moderate strength of gas, whereas the same concentration applied when the fruit has matured may produce no injury at all. The epidermis and the cells immediately beneath in immature fruit seem to be much more susceptible to injury from gas penetration than those in mature fruit.

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[17] For comprehensive treatment of this subject, see Bull. 907, U. S. Department of Agriculture, 1920.

GAS INJURY THROUGH ABRASION OR PUNCTURING OF THE SKIN OF FRUIT.

It is of common occurrence to see injured fruit in the very tops of fumigated trees When both tents and fruit are dry severe injury is infrequent, but should either or both become very wet severe injury might follow. Especially is this true after fumigation in damp weather on loose, sandy soil. Damp tents collect sand, and when drawn over the trees scrape the fruit, causing abrasions of the epidermis. Once the epidermis is abrased and the cells beneath exposed, the absorption of the gas apparently intensifies the injury, which spreads and usually results in the collapse of a considerable area of skin. These spots are called pits or burns and do not show for from one to three days after fumigation.

Where trees are fumigated under ideal conditions and some fruit is pitted, a close inspection will reveal that many of these pits are in places where the fruit has been abrased by contact with tents, poles, branches of the tree, or other fruit. If the poles are placed well in toward the tree so that they scrape or throw about branches or fruit in covering, abrased fruit sometimes results, especially in damp weather. The tents weigh down the branches and move them more or less severely during the covering of a tree. Where fruit comes sharply in contact with the ragged edge of a branch abrasion of skin is likely to follow. A heavy wind which beats the branches about will also cause much abrasion. Moist weather intensifies this condition. Sometimes, in separating fruit on a cluster after fumigation, pits are found at points of contact. This might be due to weakness of the epidermis, the resut of one fruit brushing against another, or insect attack, which is frequently localized in such protected places. In certain cases insects which frequent citrus trees unquestionably play an important part in pitting. Fruit injured by fumigation has been seen which, at the time of treatment or shortly previous, was severely infested with mites or red spiders. A heavy defoliation of red-spider infested trees was of common occurrence from fumigation during the season of 1920.

Unless the skin has been abrased or weakened shortly before the treatment, well-grown fruit on healthy citrus trees is seldom injured by the average dosage applied under proper weather conditions.

CONDITIONS OF WEATHER DURING WHICH GAS INJURY IS LIKELY TO RESULT.

Unfavorable weather conditions at the time of fumigation are often responsible for injury to trees and fruit. In the following paragraphs various meteorological elements are discussed briefly.

LIGHT.

Fumigation is carried on largely at night. The actinic rays of light intensify plant injury both during and immediately after fumigation. Plants fumigated in direct sunshine or exposed to direct sunshine within one or two hours after treatment are especially subject to injury, the degree depending upon the strength of gas used, the length of exposure, and the temperature of the air. Plants fumigated in diffused light appear to be no more injured than those fumigated in darkness.

During hot summer weather fumigation is performed at night, but as the season advances and the days become cooler the time of starting is extended so that work is commenced before the sun has set. With the advent of winter and dormant trees fumigation may be safely started on cool days early in the afternoon, provided the dosage is not excessive.

Daylight fumigation with pot or machine-generated gas should not be attempted on hot, sunshiny days, or even on cool, sunshiny days during the growing season. Although daylight work has been successfully performed with field-generated gas on warm days through reduction of dosage and length of exposure, the method is too hazardous, in view of the present state of knowledge, to be recommended. The limitations for liquid hydrocyanic acid are less restricted than for pot or machine-generated gas.

Since liquid hydrocyanic acid has come to be used in fumigation, daylight practice is no longer considered a dangerous experiment. During the winter months outfits operate throughout the daytime in bright sunshine, in many cases with complete safety and under conditions which in the past with pot or machine generated gas were wont to produce severe injury. Outside of possible differences in physical properties of the gas due to the method of generation and application, the one most plausible reason for the increased safety of daylight operation is the difference in diffusion throughout the tree. In pot-generated gas the greatest concentration is toward the tree top, the point of maximum temperature, whereas with the liquid hydrocyanic acid in warm weather the greatest concentration is toward the bottom of the tree. One fumigator in California now operates exclusively in the daylight with liquid gas and has worked out a sliding scale of dosages and exposures for the different temperatures. As compared with night fumigation, the dosages are only slightly reduced, but the length of exposure during the growing season approximates not more than one-half the usual night exposure, or 25 to 35 minutes. In daylight work particular attention is given to the season of the year, the soil condition, general health of trees, and topography of the land. Although enough daylight work has been carried on in California to show that operation with liquid gas in the sunlight is practicable under certain conditions, the limitations of these conditions have not yet been sufficiently established for a fumigator safely to attempt daylight work during the growing season without extended personal experience in that particular locality. Temperature and sunshine intensity are primary factors to consider, but are not always safe guides. Instances have been noted of more severe injury closely following sunrise than during the afternoon at much higher temperatures. Then there is a marked difference in the susceptibility of different varieties. Navels appear to withstand sunshine fumigation with liquid gas a little better than Valencias, but lemons are far more resistant than either; in fact, the dosage can be materially increased and the exposure lengthened on lemons without damage. The fumigation of lemons in the sunshine with dosages of 110 and even 120 per cent schedules for one hour with apparent safety has been observed in different parts of southern California during the winter season. However, the dosage system for winter daylight fumigation followed by several California fumigators with considerable success approximates the following: At temperatures below 65° F. a 110 per cent dosage for lemons and 100 per cent for oranges, exposure 40 minutes. At temperatures from 65° to 75° the exposure is often shortened to 35 minutes. On cool days after midafternoon the dosage is increased 10 per cent over the above figures or the exposures lengthened.

Sunshine fumigation at low humidity appears more to be feared than at high humidities.

The injury characteristic of daylight fumigation is severe leaf drop on the sunward side of the tree. Fruit is seldom injured. When fruit injury occurs it is commonly a bleach or burn on the sun-exposed surface—seldom the pitting which so often characterizes night fumigation injury.

TEMPERATURE.

Heat.—Temperature exerts one of the most important modifying influences on injury from fumigation. The actual temperature during the treatment is not the only heat influence, but the temperature after the exposure directly influences the result and also that before the exposure, but to a much less extent. Very little injury appears to result from the heat factor alone at temperatures upward to 70° to 75° F. with the schedules commonly used, but it is well to hold these temperatures as the maximum for general work. At certain seasons of the year, particularly in some sections, it has been found safe to fumigate well above 70° F. Fumigation in the citrus districts of central California during July and August is started at temperatures as high as 85° F. without injury. This safety at high temperatures is largely attributable to the hardened or resistant condition of the trees, brought about by long-continued exposure to a hot, dry summer climate. Fumigation at such high temperatures in the more humid coastal districts where trees are physiologically active throughout the summer would be apt to produce severe injury. Humidity influences in some degree high-temperature fumigation. This is well illustrated by fumigation in some coastal districts. While it is ordinarily unsafe to operate there above 70° F. it has been found that during protracted periods of warm, dry weather work could be started at 75° F. with safety. Furthermore, in the hotter, interior valleys of southern California the general temperatures at which fumigation is carried on are considerably higher than nearer the coast. Winter work, particularly with liquid gas, has been performed by some fumigators at temperatures upward to 80° F. In daylight fumigation the temperature is of primary consideration and should in large part guide the dosage.

Cold.—Experience has shown that fumigating trees at a temperature near the freezing point often results in severe injury. In some instances treatment has been carried on with impunity at a freezing temperature, but the risk is too great to justify such treatment of citrus fruit trees. It is recommended that all fumigation be discontinued when the temperature drops to 38° F.

It has been noted that fumigation on nights when the temperature fell below freezing sometimes produced severe injury to trees dosed at temperatures as high as 40° or 42° F. a few hours prior to freezing. Therefore it would appear advisable on nights when frost warnings are sent out to stop fumigation at 45° F. Undoubtedly humidity has a very direct bearing on the temperature at which injury occurs. The results of some California fumigators indicate that the most dangerous nights are when the humidity is low and the wind from the north. It is on such nights that temperature drops are most sudden. A high degree of moisture in the air tends to check a rapid drop in temperature and to protect the fruit from freezing. Fruit injured from fumigation at too low temperatures takes on a scalded appearance, loosens at the buttons, and drops within a few days following the treatment. There may be a complete shedding of fruit without noticeable leaf injury.

Where liquid gas is applied as a vapor, most fumigators consider it generally less effective at low temperatures and advocate that work be stopped at temperatures lower than 50° F., others place 45° as the limit. while a few fumigate with liquid gas to 40°.

WINDS.

Fumigation should never be attempted during heavy winds for two reasons: First, the gas is blown out of the tent, so that poor work results; second, injury to trees may occur. The burning of fruit and the dropping of foliage during heavy winds have been observed frequently. One fumigator who checked his entire season's work reported results during even a slight breeze decidedly poorer than when calm. A safe guide to follow is to discontinue fumigation as soon as the wind is sufficiently strong to cause the tents to flap. In California there are winds called locally "Santa Ana," or "electric," which are the result of storms in the surrounding desert, and fumigation during these periods is especially to be avoided, as they are accompanied usually by high temperatures and low humidity.

MOISTURE.

Although hydrocyanic-acid gas in the presence of water readily passes into solution, it has been proved definitely that the presence of water alone on citrus trees, even in excessive amounts, is in no way responsible for burning by possible absorption of gas.

There are other reasons of an indirect and largely mechanical nature, however, which necessitate the consideration of moisture. (1) The presence of moisture increases the weight of the tents, rendering them more difficult to handle, which results in much injury to fruit and branches. (2) On light, sandy soil, damp tents collect much dirt and injure fruit by scraping when being pulled over trees. (3) Moisture affects the fiber of the cloth, rendering it more impervious to gas; a wet tent becomes almost gas tight. Therefore in fumigating large trees on a damp night more gas accumulates in the tops of the tents than is normally the case. This intense strength of gas sometimes causes pitting, especially with varieties least resistant to hydrocyanic-acid gas.

Doubtless the chief cause of fruit injury is the action of hydrocyanic-acid gas on skin abrasions produced by covering the tree with wet, heavy tents. Entire rows of trees have been seen in which fully half of the fruit had been rendered worthless from severe gas burning at tent-scraped surfaces. Considering the disadvantages and resultant injury in the use of wet tents, it is evident that fumigation should be discontinued as soon as the leaves and fruit become thoroughly moist.

Air moisture, or humidity, is one of the principal factors which make fumigation less safe near the coast than in the warmer interior valleys. The low humidity in the interior tends to harden the trees and also keeps the tents dry, while near the coast the high humidity has the opposite effect. The increased gas-holding qualities of damp tents and the corresponding increased injury to trees fumigated with such tents have led to attempts to avoid this injury by reducing the dosage as the humidity rises above a certain point. It has not proved entirely practicable to work out a sliding dosage schedule based on humidity alone. Tents sometimes become very wet at a relative humidity of 88 to 90, whereas on other nights tents will remain dry at a humidity even as high as 93. Any humidity chart that does not take cognizance of the actual condition of the tent is not likely to be broadly adopted. The presence of moisture on trees does not appear to reduce the efficacy of hydrocyanic-acid gas against scale insects. Such gas absorption as occurs is more than offset by the reduced leakage through the damp tents; in fact, when tents become really damp some fumigators have followed the practice of reducing the dosage 10 per cent to avoid increased injury, it being maintained that the scale kill equals that with the higher dosage and dry tents.

Although it has been stated that the greatest influence of humidity during fumigation was through its action on the tenting by increasing or decreasing its gas tightness, it appears at times to have also a direct influence on injury. At temperatures below 40° F. it appears that a humidity of 50 or 60 is far more dangerous than a humidity of 90, particularly if the temperature later in the night drops below 32° F. At high temperatures explanations of the humidity factor usually end with the monosyllable "if." In Tulare County fumigation is carried on for weeks with almost complete absence of burning at humidities usually ranging from 35 to 70, yet later in the season with higher humidity injury is frequent. In Orange County with humidity ranging from 60 to 100 injury is most prevalent at 88 and above when the tents become damp. The exceptions to this condition are periods of very low humidity, 0 to 40, especially when these dry periods follow periods of high humidity. Such weather in southern California is usually accompanied by desert storms, and the air appears surcharged with electricity. Fumigation at such times is sometimes followed by very severe injury, particularly the pitting and burning of fruit, and the safest policy is to discontinue all operations until the weather becomes more settled. One indication of especially treacherous fumigation weather is fluctuation of the temperature over several degrees, accompanied by puffs of warm air.

With gas-tight covers moisture produces results inferior to those accomplished under dry conditions. A very dilute gas is used with gas-tight covers. Apparently absorption of gas by the moisture further dilutes the gas.

EFFECTS OF FUMIGATION ON UNHEALTHY TREES.

Occasionally a part or all of an orchard is composed of trees weakened by lack of such essential treatments as proper cultivation, fertilization, or irrigation. Many orchards contain trees weakened by attacks of gum disease, scale insects, gophers, and numerous other agents which check their normal development. These unhealthy trees are more susceptible to injury from fumigation than are perfectly healthy ones, and a dosage which in no way would affect a perfectly healthy plant is likely to cause pitting of fruit and shedding of leaves.

INFLUENCE OF SOIL CONDITIONS ON FUMIGATION INJURY.

The moisture conditions surrounding growing plants have been shown to influence their development and susceptibility to injury from fumigation, those growing under moist conditions being less resistant to gas than those growing under dry conditions. The mere wetness of the soil does not in itself offer full explanation of plant injury due to this factor. For instance, the fumigation of orchard trees immediately following a heavy rain has been done with no more injury than to trees in dry soil. Likewise, fumigation frequently follows immediately after an irrigation without noticeable damage to the trees. The writer believes that the greater injury to citrus trees in wet soil comes from changes in foliage or fruit induced from being subjected to a very moist condition for a sufficiently long period to make them less resistant to hydrocyanic acid. This position is supported by the results of soil investigators to the effect that soil moisture in excess of the optimum leads to depressed growth, light-colored foliage, and general lack of vigor, the visible damage being greater than if the moisture condition is below the optimum. It is often noted in fumigation on sloping or rolling ground that trees in the swales, low spots, or so-called wet spots are more subject to injury than those on the higher ground. Instances of severe leaf drop following the fumigation of trees near leaky irrigation stands have been reported. Although a dry soil tends to slacken growth and hasten maturity of plants, thereby rendering them more resistant to hydrocyanic acid, it has been observed that protracted situation in soil so deficient in moisture that the plant suffers ultimately leads to a physiologically weakened condition. It has been stated elsewhere in this bulletin that plants in a state of impaired health are more susceptible to injury than normal healthy plants.

The soil type also appears so to influence the physiological condition of the tree that modified reaction to hydrocyanic acid sometimes occurs. A 30-acre lemon orchard which was fumigated experimentally in 1918 was about equally divided between two distinct soil types, one a loam designated as a " barren " soil, the other black adobe which contained about 10 per cent humus. Injury occurred throughout this orchard, but the degree was noticeably greater on the loam than on the black adobe. Other instances of injury due to different soil types have been noted. Groups of trees whose growth has not kept pace with the rest of an orchard, owing possibly to inferior subsoil, to hardpan, gravel, etc., are not uncommon. Trees under such adverse conditions have sometimes been more adversely affected by fumigation than healthier trees.

Plants best resist cyanid gas if in a hardened or dormant condition at the time of fumigation. Hardening is brought about either by cold weather or by a dry soil. Since citrus is mostly grown in countries that practice irrigation, the dryness of the soil can be regulated by regulating irrigation. As a general rule, therefore, fumigation should precede the run of water rather than follow, as is frequently the practice at the present time.

STRENGTH OF GAS CITRUS TREES WILL STAND WITHOUT INJURY.

The lemon tree is much more resistant to injury from fumigation than is the orange or grapefruit and seldom suffers appreciable damage when treated under normal conditions with either Schedule No. 1 or the three-fourths schedule. Some varieties of oranges are injured more easily than others. Of the varieties of commercial importance in California, the Navel and Valencia are the least susceptible to injury from gas treatment. The seedling is almost equally hardy, while the tangerine (mandarin) stands the gas quite well. The Mediterranean Sweet is not quite so resistant to the gas as are the preceding varieties, and the Homosassa and St. Michael are easily injured by fumigation. It is inviting damage to fumigate the last two varieties with Schedule No. 1, and injury might result with the three-fourths schedule unless prevailing conditions were favorable. Fortunately, the Navel, the Valencia, and seedlings comprise the bulk of the oranges grown in this State.

In general a strength of gas up to the three-fourths schedule, and in some districts Schedule No. 1, can be used on citrus trees with a minimum amount of injury if care be exercised. In Tulare County a 110 per cent schedule is safely used, except at the start of the season. This same schedule is sometimes used in the interior valleys of southern California toward the close of the season. In recent years, with increased resistance of some scales, dosages of 125 per cent strength have come into practice. Such high dosages have been found unsafe on oranges during the growing season unless the exposure is shortened.

As fruit on the tree matures its resistance to gas injury increases. Fruit in transport or in storage appears to be more resistant to gas injury than fruit on the tree.

FUMIGATION INJURY TO SPRAYED TREES.

Orange trees frequently are sprayed for the control of certain insect pests or plant diseases. The sprays in common use are Bordeaux mixture, lime-sulphur solution, and petroleum oils. If trees are fumigated after the application of Bordeaux mixture, injury will result, especially during damp weather. The most characteristic type of injury is defoliation, and this is often accompanied by severe fruit pitting. (Fig. 33.) Although it is for the most part safe to fumigate six months after spraying, injury has been noted in a few cases as late as 11 months after the spray was applied. Injury after such an extended period, however, appears to be brought about by very heavy dosages, wet tents, weak trees, or possibly an excessive use of strong Bordeaux. It is a common practice in California to spray the lower branches of citrus trees and the ground in the late autumn or winter to prevent brown-rot of the fruit. Where such spraying is done it should follow fumigation, not precede it. Furthermore, at least two or three days should elapse before a fumigated orchard is sprayed with Bordeaux mixture in order to allow the tree time to recover entirely from the shock of fumigation. The injury in the case of trees sprayed only at the bottom is not necessarily confined to the sprayed part, and many cases have been recorded where trees fumigated from a few days to a few months after the spraying were almost completely defoliated, in sprayed as well as unsprayed portions. Such defoliation has been decidedly more pronounced with orange trees than with lemons. Where conditions arise in the case of skirt-sprayed lemons which convince the grower that he can not afford to delay fumigation for six months after the Bordeaux application, the injury risk can be greatly reduced by avoiding daylight work, by avoiding strong dosages, and by fumigating at low humidities (not over 85) with thoroughly dry tents.

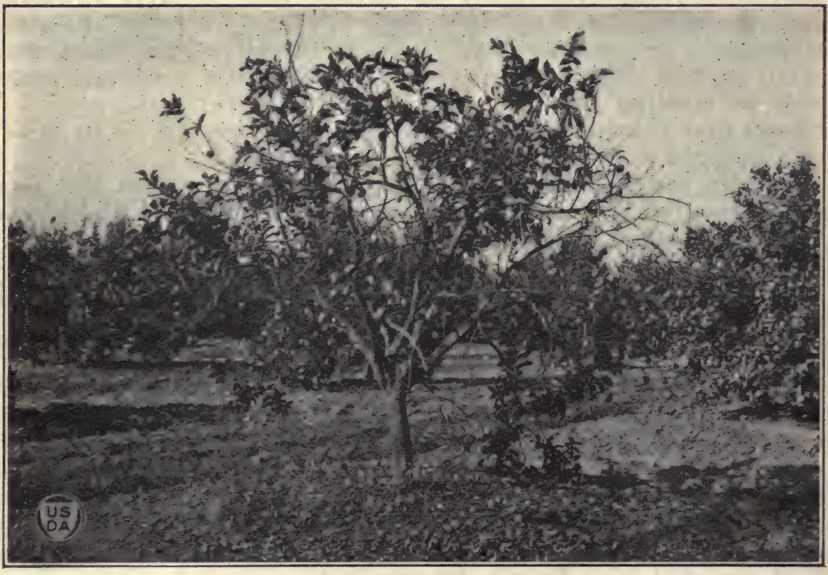

Fig. 33.—A lemon tree defoliated from fumigation following spraying with Bordeaux mixture. Entire tree sprayed in January and fumigated with 110 per cent schedule the following September.

The trunks and branches of citrus trees are painted with Bordeaux paste to cure certain gum diseases. Where only the main trunk is painted, fumigation is usually performed with safety at any time, even immediately after the treatment. Particularly is this true of lemon trees, and very seldom has a trunk-painted lemon been injured unless the tree was very young or severely scraped before the Bordeaux application. Valencia trees are most susceptible of all varieties, and some cases of severe injury have been observed from the Bordeaux being washed by rains into the soil and entering the tree through the root system. There is considerable risk of severe damage from fumigation, particularly with oranges, where the trunk painting is extended well up into the branches, or where the branches alone are coated. The basis of this trouble is probably the copper in the Bordeaux paste, for copper readily combines with cyanid in a very toxic compound. The copper might be absorbed through the foliage or tender bark or taken up by the roots if washed into the soil. The risk of fumigation injury has induced some growers to discontinue the use of Bordeaux above the main trunk in favor of certain carbolineum or creolineum preparations which do not react with cyanid gas; in fact some growers use these latter materials exclusively for treating diseased trunks, as well as branches and roots. It appears that Bordeaux-treated trees are more susceptible to injury from daylight work than from night fumigation.

Recently some fumigation tents of green cloth which had been mildew-proofed by a copper salt were introduced into California. These tents when new injured the trees in a manner typical of Bordeaux effects.

Trees previously treated with an oil or sulphur spray can be fumigated without injury other than that which might occur on unsprayed trees. If the trees are weakened by the use of oil sprays, however, fumigation may cause leaf drop.

UNEXPLAINED INJURY.

Probably the most unsatisfactory part of fumigation to grower and fumigator is diagnosing cases of injury. Most of the factors which bear on this problem have been stated, but when considered as a whole they are somewhat confusing and not always tangible. Furthermore, injury frequently occurs, the causes of which can not be fully explained. This unexplained injury further confuses the situation. Numerous cases of unexplained injury occurred on October 13 and 14, 1921, when orchards in widely separated districts of southern California were severely damaged from fumigation. Other treated orchards in the same districts were uninjured. The damage, which amounted for the most part to leaf drop, continued throughout the night. The weather appeared well suited to fumigation. For several years it has been noted that there is a period during the last part of October and early November when fruit pitting is of frequent occurrence—decidedly more frequent than in work either before or after this time. During 1921 this condition was so pronounced in some districts, particularly toward the coast, as seriously to interfere with the progress of the work. While it is believed that the period of susceptibility to fumigation corresponds with certain physiological changes within the trees, nothing sufficiently tangible has been developed to make possible avoidance of the injury. There are periods of the year when dry desert winds blow over the citrus districts of southern California, and the air often appears surcharged with electricity. Fumigation at such periods sometimes leads to severe injury; at other times, under practically identical conditions, no injury occurs. Cases have been reported where severe injury followed fumigation immediately preceding a heavy rainstorm, yet there are innumerable cases of fumigation before a rain without any injury whatsoever. Fruit pitting might be of common occurrence in one orchard, although an adjacent one treated at the same time was uninjured. Difference in physiological conditions of the trees or in soil relations which might explain the injury are not sufficiently tangible to satisfy the average grower whose fruit is injured.

Some fumigators believe that fruit pitting is sometimes more pronounced in pot or machine fumigation than in liquid-gas work. On the other hand, foliage injury sometimes is more severe in liquid-gas work with the applicator than where a warm gas is supplied from the pot, fumigating machine, or vaporizer.

FUMIGATION OF TREES IN BLOOM.

Ordinarily the blossom growth is quite resistant to fumigation and work can be conducted with safety right up until the petals fall. There have been seasons, however, when the blossom growth, particularly on Valencias, appeared to be quite susceptible to injury for a period commencing when the growth was about a half inch long up to the time the blossoms were well formed. When fumigating with strong dosages during the bloom, therefore, give careful attention to the effect of the gas during this susceptible period, and if severe burning occurs discontinue work until the blossoms are well developed and in a condition when they will withstand the gas treatment. The bloom on lemons is decidedly more resistant to fumigation than that on oranges and is seldom seriously injured at any time of year.

CITRUS INSECTS AND THEIR CONTROL.

CITRUS PESTS AGAINST WHICH ORCHARD FUMIGATION MAY BE PRACTICED.

Fumigation with hydrocyanic-acid gas is especially adapted to the control of scale insects and white flies, which live a part or all of their existence attached to the plants, and, as practiced at the present time, orchard fumigation is confined almost exclusively to the control of this class of insects on citrus fruit trees.

DIRECTIONS FOR CONTROLLING VARIOUS CITRUS PESTS.

Much experimental work with fumigation against various citrus pests in California and Florida has resulted in definite records of the successful control of these insects. Insects such as the white flies and armored scales, which can be destroyed in practically all stages of development, can be fumigated at any time the trees are in a condition best fitted to resist injury. In general, soft or unarmored scales are very resistant to hydrocyanic-acid gas in the mature and egg stages; it is advisable, therefore, to fumigate these pests during their breeding season while the insects are in the immature stages.

Black scale.[18]—The black scale has been developing resistance to fumigation in some localities. A decade ago it was readily controlled anywhere in California in the immature stages by the use of a three-fourths (75 per cent) schedule. To-day this strength of gas has little effect on the scale in some important districts. This has led to the more or less general practice in recent years of applying as heavy a dosage as the trees will safely stand. The preferred method is to start the season with an 85 per cent dosage and raise to 100 per cent (No. 1) as soon as possible. In districts where 100 per cent is too low, the dosage should be raised to 110 or even 120 per cent late in the season. A 110 per cent dosage is probably about the limit which orange trees will stand, except when hardened by cold weather. A 100 per cent schedule appears to be about the limit of safety during the growing season on oranges in the coastal districts. Most fumigation for the black scale is done from August to December. In some localities toward the coast this scale insect is somewhat irregular in development and best reached by fumigation in July or during the winter months. The exposure should be one hour.

Red scale.[19]—The red scale, like the black scale, is also developing immunity to fumigation in some localities. The three-fourths or 75 per cent schedule which cleared the trees of this pest a few years ago is now effective only in a few interior districts. In parts of Riverside and Orange Counties dosages even as high as 125 per cent have not given thorough satisfaction, and sometimes two fumigations a year are required. Although the red scale is susceptible to cyanid gas at any time of the year, in these districts of resistant scale it appears preferable to delay fumigation until winter, December to March, if possible, when a much heavier dosage can be safely used. Lemon trees will then usually withstand a 125 per cent dosage for 45 minutes or 1 hour. Some fumigators have used a dosage as high as 150 per cent on lemons for 30 to 40 minutes and report good results. A dosage of 110 per cent is usually the limit on oranges. Red-scale control by fumigation can not be considered entirely satisfactory in some districts.

Purple scale.[20]—A 100 per cent schedule is required for thoroughly effective results against the purple scale. In warm weather an 85 per cent schedule has proved fairly satisfactory. A good practice is to start the season with an 85 per cent schedule and increase to 100 as soon as the fruit develops resistance to the gas. Never use less than an 85 per cent schedule for this insect. The best season to fumigate is August to December. Never fumigate for the purple scale during the winter, for at this season the eggs are very difficult to destroy. Exposure should last for one hour.

Citricola scale.[21]—Start the season with 85 per cent dosage and increase to 100 or even 110 per cent as soon as possible for the citricola scale. Fumigation for this scale is most successful in July and August. Satisfactory work can sometimes be done the first part of September. Late autumn or winter fumigation against this pest has proved unsatisfactory. Exposure should last from 45 minutes to 1 hour.

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[18] *Saissetia oleae* Bern.
[19] *Chrysomphalus aurantii* Mask.
[20] *Lepidosaphes beckii* Newm.
[21] *Coccus citricola* Camp.

Yellow scale.[22]—Use 88 to 100 per cent schedule for 45 minutes. Fumigate at any time of year. If winter fumigation is done use 100 or 110 per cent dosage.

White flies[23] **and Florida red scale.**[24]—Start with 85 per cent dosage and raise to 100 per cent as soon as possible. Fumigate in Florida from December to February. Expose 45 minutes to 1 hour. Daylight work with liquid gas might prove to be the most successful method in Florida through avoiding the high humidity more or less prevalent at night.

LENGTH OF EXPOSURE.

In fumigation with untreated cloth tents practically all of the gas escapes before the expiration of one hour unless the weather is very damp. Experience in orchard fumigation has shown that an exposure of 45 minutes for most insects gives practically as good results as that of an hour. Where eggs are present, the one-hour exposure results in slightly more effective work.

TIME OF YEAR FOR FUMIGATION.

Many of the scale insects can be destroyed easily by fumigation at any stage of development. These insects may be fumigated at any time of the year, and include such species as the red, yellow, and purple scales. Other scale insects are very resistant to treatment in the egg and adult stages. This type of insect, which includes such species as the black, hemispherical, and soft brown scales, must be treated in the early stages of development, when they are least resistant to the gas.

Unfortunately, citrus trees are not in a condition to resist gas injury equally well at all times of the year, and care must be used to see that fumigation is carried on under the most favorable weather conditions and when the fruit is of fair size. It is preferable, of course, to fumigate after the fruit has been picked, but this is seldom possible in California. The principal season for orchard treatment in California is from the 15th of July to the middle of December; in Florida the season most suited for fumigation would appear to occur between the first of December and the end of February, the approximate period of tree dormancy and minimum rainfall.

REMOVAL OF OLD SCALY FRUIT.

Scale insects on fruit are usually more difficult to destroy than those on the leaves or branches. Especially is this true for an egg-laying species such as the purple scale. When fruit is picked, a few old scaly oranges are occasionally left on the trees. Such fruit should be removed before fumigation, lest it become a source of reinfestation after the other parts of the tree have been cleaned.

SUCCESSIVE TREATMENTS.

As stated, some scale insects are very resistant to fumigation in the egg and adult stages, though easily destroyed in the immature stages. Occasionally plants which will not stand a high concentration of gas are infested with all stages of scale insects, and if the eggs and adults are very resistant it is possible to control the pest through the destruction of the immature insects by using a concentration of gas which will not injure the plants. In such cases successive fumigations are necessary; the first will destroy all the immature insects present at the time of treatment, and fumigations repeated at the necessary intervals will destroy all the insects hatching since the preceding fumigation. This work necessitates a knowledge of the life history of the insect concerned.

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[22] *Chrysomphalus citrinus* Coq.
[23] *Aleyrodes* spp.
[24] *Chrysomphalus aonidum* L.

COOPERATIVE FUMIGATION.

In California there are three systems of fumigation: (1) The contract system, under which parties having one or more fumigation outfits contract with growers to do their work at a certain amount per tree; (2) private ownership, where owners of large groves do their own fumigation work; and (3) cooperative fumigation.

Throughout California citrus-fruit growers are organized into cooperative associations for handling their fruit, which is marketed through a central organization, the California Fruit Growers' Exchange. Many of these local associations own and operate their own fumigation outfits for the benefit of their members. In recent years the tendency of growers to handle their own fumigation has led to the formation of large cooperative fumigation companies, which include the members of several citrus associations. These cooperative companies are formed by the growers in a community getting together and agreeing in writing to finance the project. A board of directors is elected and plans made for a capital stock organization. Each acre of orchard coming in is assessed a certain amount of stock. With the first companies this was $5 an acre, but experience has proved $10 or $15 an acre a more workable basis. Part of the stock is paid in cash, and the balance by an annual tax on each box of citrus fruit produced by the orchard. If a sufficiently large acreage joins to make it a going concern the company is organized and a manager of recognized ability is selected to run the business. Cooperative fumigation has been a big success, and the extent of the success has been directly in proportion to the ability of the manager. Copy of a typical contract between the grower and the fumigation company follows:

> I, the undersigned, hereby subscribe for and agree to buy, take and pay for ____________________ shares of capital stock of the Orange County Fumigation Company, a corporation, at the price of $1.00 per share, par value, and herewith tender the one-tenth part of the purchase price thereof; the remainder of the purchase price thereof to be paid at the rate of one cent per packed box of citrus fruits produced from the property for which stock is issued, including current packing season, which one cent per box, the Manager of ______________ ________________ Association is authorized to pay the Orange County Fumigation Company until such stock is fully paid up, provided, however, that at least an additional one-tenth of the purchase price of said stock shall be paid each year, including the current year, until said stock is fully paid.
>
> By this subscription I am subscribing for sufficient of said stock so that with stock, if any, already owned or subscribed for by me in said corporation I will become the owner of ten shares of said stock for every seventy-five trees or fractional part thereof of citrus fruits owned by me upon which service by this corporation is desired. The provisions of this subscription contract shall be construed with any other subscription heretofore made by me so as to require

the payment of an aggregate of one cent per said packed box to be applied on the purchase price of all stock so subscribed for, with a minimum payment of one-tenth of said price.

Subscriber.

RESPONSIBILITY FOR FUMIGATION INJURY.

Leaf-drop and fruit injury occur to a greater or less extent every fumigation season. When the crop damage is severe the grower may be inclined to place the responsibility for the damage on the fumigator, particularly if he considers that the fumigator employed inexperienced help or that the work was carelessly done. The causes for fumigation injury are in many cases so elastic and so little understood that the adjustment of injury complaints to the mutual satisfaction of the grower and fumigator is seldom obtained. Cyanid gas is toxic to plant life, and in citrus trees injury sometimes occurs even when a 75 per cent schedule, the minimum for orchard fumigation, is employed. As the dosage is increased above this point the risk from injury is correspondingly greater. Most scale pests require a dosage approximating a 100 per cent schedule if they are to be effectively controlled; in some districts an even higher dosage is necessary. These high dosages mean that fumigators are operating most of the time in the danger zone. When the weather is right and the trees in a physiological condition resistant to cyanid gas, work progresses with little trouble. This is normal to most fumigation. When, however, serious injury occurs and the responsibility must be determined, the question arises, " Did the injury result from inexperience and negligent methods employed by the fumigator or is it attributable to causes which were to all intents and purposes unavoidable, beyond the control of the operator, and happened in spite of his efforts to do a careful, effective job?" If the damage can be attributed to negligent methods, the fumigator is in part or wholly responsible. If the fumigator possessed a working knowledge of the principles of fumigation and performed his work carefully and with due regard to the generally observed rules, then injury, should it occur, must be considered as one of the hazards of the work and be borne by the grower, unless the fumigator voluntarily decides to make an adjustment. Fumigation at freezing temperatures, at very high temperatures, in a strong wind, when the tents are very wet, and guessing at the dosage instead of measuring—all constitute careless fumigation. Injury from a heavy dosage employed by the fumigator in an effort to do a satisfactory job can scarcely be considered negligence, unless the dosage was well above any used in other orchards in that particular district and was done without the prior understanding or consent of the grower.

COST OF FUMIGATION.

The cost of fumigating an orchard depends primarily upon the size of the trees and the dosage rate used. Trees 1 to 3 years old which can be covered with 30-foot tents may not cost more than 20 cents each to fumigate, whereas large seedlings often cost $1 to $1.25 each. One large California citrus ranch of 600 acres expended

$17,000 for fumigation in 1921. The average citrus orchardist in California expends $25 to $40 per acre for one fumigation treatment, or an average of 35 to 45 cents per tree. The cost to the grower is usually based on three factors, namely, covering, chemicals, and drayage. The covering cost for 45-foot tents in 1921 averaged 20 cents per tree. The factory cost for liquid hydrocyanic acid was 70 cents per pound, but many fumigators charged the growers 75 cents, the extra 5 cents to cover hauling and loss of material. Solid sodium cyanid is usually 35 cents a pound, this cost to include all the sulphuric acid necessary to generate the cyanid and hauling the chemicals to the field. This charge applies alike to pot and fumigation machine. Cooperative fumigation companies base their charge to growers on approximate cost. This cost includes such items as chemicals, labor, drayage, and overhead (tent rent), the latter to include depreciation of equipment, repairs, insurance, and administration. Most concerns figure tent depreciation on a five-year turnover. Depreciation is frequently lumped with other overhead costs, including labor, and all included in a tree-basis assessment. The figures in Table 7, which are the combined averages of several large companies owning a wide range of tents, should prove helpful to new organizations in arranging a program of costs. These figures are averages of both coast and interior fumigation, handled on a large scale. Concerns operating during the dry season in the interior valleys, or whose work is confined largely to medium-sized or small trees, should cover a larger number in a season than the figures given in the table indicate, and thereby have slightly lower depreciation costs per tree. Where a concern has only a few large tents for covering a small number of scattering large trees the depreciation per tree covered will be high. In such cases a common practice is to make the small sizes help pay for the depreciation of the large sizes.

TABLE 7.—*Tent depreciation, general overhead, and labor costs for fumigation on a tree basis.*

[The figures are averages based on the experience of several large California fumigation concerns.]

Tent size.	Cost of tent.	Average number of trees covered by one tent each year.	Cost per tree.		
			Tent depreciation.	Depreciation and other overhead.	Labor.
36	$38	450	$0.02	$0.065	$0.06
42	56	400	.03	.08	.07
45	60	350	.035	.095	.09
48	72	300	.05	.11	.125
52	85	225	.075	.15	.155
60	112	200	.115	.20	(1)

[1] By hour.

One fumigation concern has decided that a cost of $3.20 per acre for 36's and $4.20 an acre for 45's will cover depreciation, mending, and drayage. Ten per cent of the total bill is charged, in this case, for administration. Some large companies report a cost per tree of about 4 cents for general overhead expenses. The labor of most outfits works on a tree basis, the foreman receiving about one-half cent per tree more than the other members of the crew. Where operating on a per hour basis the average hourly wage for pullers during 1921 was about 70 cents and for the foreman 85 cents. It is customary to allow 50 cents a man for the roll up of tents at the completion of each job. Some concerns pay 25 cents a man for the last pull off of tents each night.

The cost of the total equipment for an outfit of sixty 45-foot tents on the basis of 1921–22 prices ranged between $3,600 and $4,500. The fumigation equipment required to handle 1,500 to 2,000 acres in some of the older citrus sections of California (approximately three hundred and twenty-five 36 to 60 foot tents, truck and trailer, and other necessary equipment) will approximate $25,000 to $30,000. The total cost during the season of 1921 for fumigation in California was almost $3,000,000, or a tax of approximately 3 per cent on the $83,000,000 citrus crop.

FUNDAMENTALS FOR SUCCESSFUL FUMIGATION.

Trees should be measured, not guessed, and dosed according to standard schedule.

A careful, experienced foreman is the keystone to safe, effective fumigation.

Use heavy dosages. Start with an 85 per cent schedule, if possible. Raise to 100 per cent as soon as the trees will stand the heavier dosage.

Fumigation during even a moderate wind tends toward poor results and is advised against.

It is poor policy to fumigate orchards heavy in cover crop.

All equipment should be kept in good repair.

Tents should be centered on trees, kicked in to hang perpendicular from the outer limbs, and the edges touch the ground all around.

It is well to keep records of individual tree dosage, temperature, humidity, and time of start and finish.

SCALES.

Black scale.—Fumigate the scale when in its youngest stages of development. The season usually extends from August to December, some coastwise orchards excepted. Use 85 to 100 per cent dosage for one hour. Resistant-type scale requires even more concentrated gas. If double fumigation is practiced, the second treatment should follow the first in two or three months.

Red scale.—From the middle of December to April is the preferred season to fumigate for the resistant red scale. The schedule commonly used on lemons is 125 per cent; on oranges, 100 to 110 per cent. The ordinary red scale can be fumigated at any time of year with an 85 to 100 per cent schedule. An exposure of 45 minutes to one hour should be given.

Citricola scale.—Fumigate during July or August with the 100 per cent schedule, and during the first part of September with the 110 per cent schedule, if possible. Do not fumigate later than the middle of September.

Purple scale.—Use 100 per cent dosage, if possible; never less than 85 per cent. Expose the trees one hour. Do not fumigate during the winter.

Fumigation of black or purple scales at temperatures near the freezing point often results in poorer scale kill than at higher temperatures.

FUMIGATING MACHINE.

Test the fumigating machine for accuracy two or three times a week.

Stir the cyanid solution in the solution tank before using.

Before fumigating a row, generate 2-ounce charges until the machine is filled with gas.

Cyanid solution will crystallize at temperatures around 40° F.

The same dosage schedule is used for the fumigating machine as for pots.

For liquid gas a slightly different schedule is used in which the dosage for large trees is somewhat increased.

LIQUID HYDROCYANIC ACID.

Liquid hydrocyanic acid is inflammable. Keep open flames at a distance from drums or applicators.

Inspect and test applicators for accuracy every day before starting work.

Direct the nozzles of applicators away from the trunks of small trees to avoid injury.

The nozzles of applicators should not be placed among weeds or cover crop, and should be within the foliage fringe of the tree.

Results from atomized liquid gas appear to be most satisfactory at warm temperatures. Preferably it should be used at temperatures above 50° F.

Vaporized liquid gas gives a better diffusion within the tent than when atomized through a nozzle.

Eighteen cubic centimeters of high-purity liquid gas is equivalent to 1 ounce of sodium cyanid for scale kill under field conditions.

INJURY.

Avoid fumigating trees sprayed with Bordeaux mixture, or painted with Bordeaux paste high above the trunks, within 6 to 10 months after application. If done at a shorter interval, fumigate only at low humidity and with dry tents.

Fumigation with pots or fumigating machine should be stopped at 36° F. on damp nights; and on dry nights, when frost warnings indicate that the temperature is likely to fall to freezing or below, complete safety demands stopping at 43° to 45° F.

Fumigation with wet tents often is the cause of severe injury. Work should be stopped when tents become wet.

Sunshine is one of the most harmful agents to plants in connection with fumigation. It exerts an influence both during and after the treatment. Safe sunlight fumigation requires a proper knowledge of dosage, exposure, and temperature influences. Without this knowledge daylight fumigation should not be attempted.

In the coastwise districts it is generally unsafe to fumigate above 75° F. In hot interior districts, where the trees harden in summer, work appears to be carried on with safety even as high as 85° F.

Sulphuric acid will burn canvas. Care should be exercised, therefore, to avoid the residue from fumigating machine or pots coming into contact with the tents.

Fumigation during periods of desert or "electric" winds sometimes produces severe fruit injury.

Trees in bloom can be fumigated with safety with moderate dosages.

Fumigation should precede rather than follow an irrigation.

Hydrocyanic acid is one of the most deadly gases known. Particular care should be exercised in handling liquid gas. Two men should always be present when filling the machine. Drums should not stand exposed to hot sunshine. Each man should be furnished with a small bottle of ammonia for use in case one of the crew is overcome. At least two men on each crew should be familiar with the prone pressure method of resuscitation.

COUNTY REGULATIONS GOVERNING FUMIGATORS OPERATING IN SOUTHERN CALIFORNIA, 1922–23.

REQUIREMENTS.

All fumigating tents shall be marked in accordance with the Morrill system.

The foreman of each fumigating crew shall be equipped with a thermometer properly tested within the range of 28° to 100° F. (See recommendation No. 8.)

All equipment used by fumigators shall be kept in good repair when in use.

No pump for liquid-gas applications shall be operated having more than 3 per cent variation from correct measurement.

Each tent shall be placed so that one line of numerals runs over center of top of tree.

Tents shall be kicked in to hang perpendicularly from outer limbs of tree to ground, and shall touch the ground on all sides.

Work must not be carried on when wind is strong enough to cause any appreciable movement of tent walls.

Each tree requiring more than a four-unit charge shall be taped and correct dosage given as called for upon chart.

Trees shall be given not less than 45 minutes' exposure regardless of dosage, and work of tent pullers shall be regulated accordingly.

Trees shall not be fumigated with pots or cyanofumer when temperature is below 37° F.

Trees shall not be fumigated with liquid gas when temperature is below 50° F.

Work shall be discontinued when tents begin to become damp.

Deviation except by the grower's consent from any of the foregoing requirements will be considered sufficient ground for the revocation of crew foreman's license or contractor's license and certificate to operate.

Each fumigator shall submit on the first of each month a report to the county horticultural commissioner showing for each piece of work performed during the previous month: Date, grower's name, location of orchard, number of orange or lemon trees, kind of material used, and strength.

Fumigator shall keep on file and furnish upon request of horticultural commissioner statement of amount of material used on any piece of work.

A chart of each orchard shall be made and kept on file for one year, showing the dosage given each tree and the temperature and time at the beginning of each set. A copy of this chart shall be furnished the grower or county horticultural commissioner upon request.

Carelessness in application of materials or other evidence of abuse of privilege to do business under license or certificate shall at all times constitute grounds for revocation of same.

RECOMMENDATIONS.

1. A written contract between grower and fumigator is recommended. Any deviation from the above requirements authorized by the grower should be mentioned therein.

2. There is considerable danger of tree injury at high temperatures. The danger point is reached in coastal districts near 75° to 80° F. and in interior districts near 80° to 85° F.

3. Daylight fumigation is not recommended at any time except as generally practiced beginning late in afternoon under most favorable cloudy conditions.

4. Care should be taken not to allow containers of liquid gas to become heated. Keep them in a shady place and keep covered with wet sacks.

5. Leakage from liquid-gas containers is extremely harmful to tree roots, and care should be taken to keep containers far enough from trees to insure safety.

6. Residue from pots or cyanofumer should be dumped far enough from trees to prevent damage.

7. Operators must bear in mind that many people are not aware of the dangerous properties of the materials used in fumigation, and every possible precaution should be taken to guard against accidents. Containers of cyanide or acid in any form should be locked or covered in such a way that the contents can not be released by children or irresponsible persons.

8. The United States Bureau of Standards, Washington, D. C., and the department of meteorology of the Los Angeles Chamber of Commerce, 800 Central Building, are properly equipped to test thermometers. The seal and certificate of either of these offices will be accepted. A nominal fee is charged for this service.

9. All tents should be numbered serially on at least two sides with black numerals not less than 4 inches in height.

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Dup

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1322

The STRIPED CUCUMBER BEETLE

AND HOW TO CONTROL IT

THE STRIPED CUCUMBER BEETLE is the most destructive of all our cucumber insect pests and does serious damage to all forms of related plants. It is widely distributed east of the Rocky Mountains and is to be found in most fields and gardens.

The adult or beetle is about one-fifth of an inch long, yellow, with three stripes running lengthwise of the wing-covers.

The beetles attack and injure seedling plants as soon as they appear, even burrowing down to meet them before they come above ground. They devour the tender stems and leaflets before the plant is fairly started, gnaw the older stems and ripe fruits, and act as carriers of cucurbit diseases. They make their appearance suddenly and in great numbers, and as they work rapidly an entire crop may be destroyed in a few days.

The young, known as worms or larvæ, although much less destructive than the beetles, injure the plants later in the season by tunneling the roots and underground parts of the stems.

To control this pest and reduce its ravages five methods are employed: Preventive measures, the use of repellent substances, dusting with nicotine dust, spraying and dusting with arsenate of lead, and good farm practice. These are described fully on pages 7 to 15 and summarized on page 16.

This bulletin is a revision of and supersedes Farmers' Bulletin 1038, The Striped Cucumber Beetle and Its Control.

Washington, D. C. April, 1923

THE STRIPED CUCUMBER BEETLE[1] AND HOW TO CONTROL IT.

F. H. CHITTENDEN, *Entomologist in Charge, Truck-Crop Insect Investigations, Bureau of Entomology.*

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APPEARANCE AND NATURE OF INJURY.

SEEDLING CUCUMBERS are injured by a small yellow and black striped beetle, known locally as "melon bug," "striped bug," and more generally as the striped cucumber beetle. Attack begins at about the time the cucumber plants are 2 or 3 inches high, though not infrequently the beetles appear a little before the plants and burrow into the ground to meet them, afterwards devouring the tender stems and leaflets before the plant is fairly started. The work of the beetle on the first leaves and stems of cucumbers is shown in Figure 1.

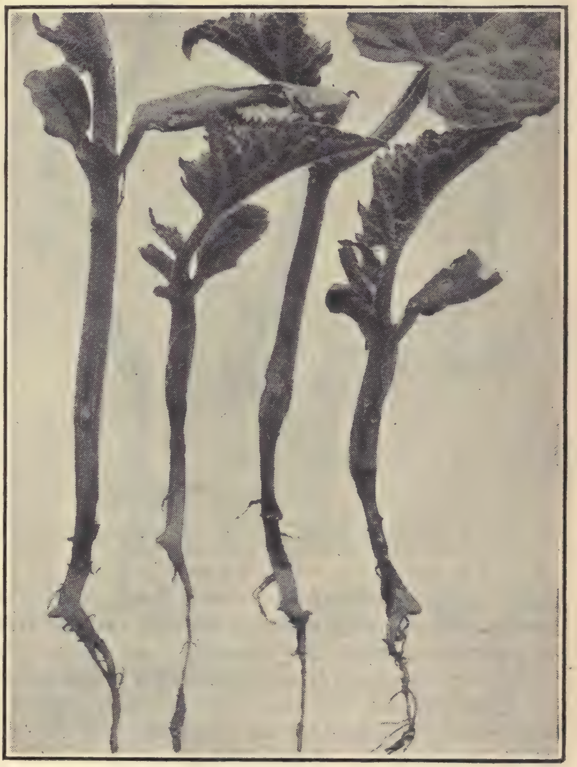

FIG. 1.—Young cucumber plants showing severe and characteristic injury by adults of the striped cucumber beetle at end of roots and in the seed leaves.

While the most obvious as well as the principal injury done by this pest is to seedling cucumbers by the overwintered beetles, severe injury is often inflicted on melons, squashes, pumpkins, and related crop plants.

Everything considered, the striped cucumber beetle is the most important insect enemy of cucurbits with which the farmer and gardener have to deal, and constant complaints are received every year of its ravages to these crops.

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[1] *Diabrotica vittata* Fab.; order Coleoptera, family Chrysomelidae.

The beetles are destructive to older plants by eating the leaves and by gnawing away and consuming the outer tissues and considerable portions of the stems, and later by devouring the rinds of the fruits and rendering them unmarketable.

The beetles cause further mischief by acting as carriers of the bacterial wilt,[2] mosaic, and other diseases of cucurbits. This is a matter of grave importance and has been the subject of special investigation by the Department of Agriculture since the year 1915.

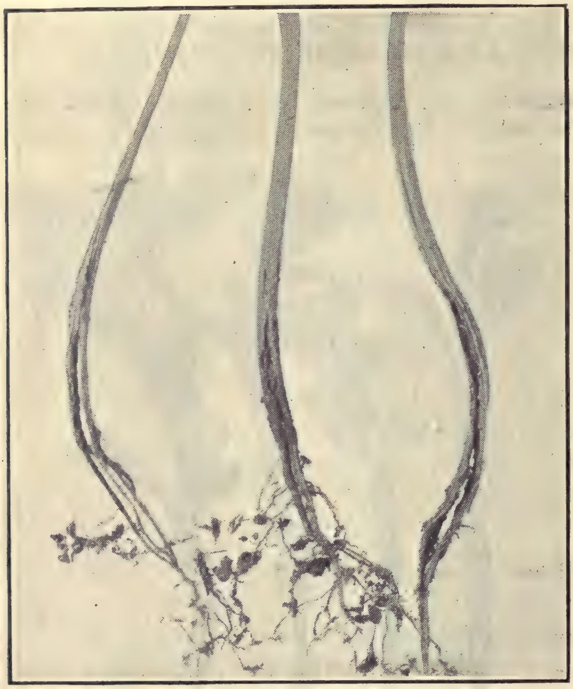

FIG. 2.—Underground stems of cucumber showing injury by larvæ of the striped cucumber beetle.

The larvæ or "worms" also are the cause of injury to older plants through their work underground in the roots and stems (Fig. 2), which they tunnel from below. The larvæ, however, are by no means as destructive as the beetles. Because of the underground feeding habits of the larvæ, more frequently than not the roots of cucurbits are being injured without the knowledge of the farmer or gardener, the outward manifestation of their presence being the wilting of the leaves and the failure of the plants to develop perfect fruit. Far too often the debility or death of the vines through the work of this insect—the larvæ at the roots and the beetles on the stems near the ground—is attributed to wilt, dry weather, or some other than the real cause.

Injury by the striped cucumber beetle, then, is threefold, due (1) to direct attack by the beetles on the plant, (2) indirectly to the beetles as transmitters of diseases, and (3) to the work of the larvæ in destroying the root system.

THE INSECT IN ITS DIFFERENT STAGES.

In the course of its life this insect passes through four stages of development: (1) the egg, (2) the larva or "worm," (3) the pupa or resting stage, and (4) the adult or beetle.

---

[2] *Bacillus tracheiphilus* Erw. Sm. *See* Bacterial Wilt of Cucurbits. Frederick V. Rand and Ella M. A. Enlows. U. S. Dept. Agr. Bul. 828, 43 p., 2 tab., 10 fig., 4 pl. 1920.

The adult striped cucumber beetle (Fig. 3, *a*) is about one-fifth of an inch long and nearly half as wide. It is yellow above, with black head and black stripes running lengthwise along each wing-cover, producing the effect of a three-striped back. The abdomen underneath is black, the neck and legs are yellow, and the antennæ, or feelers, are mostly black. The feet and knees are black.

The egg (Fig. 3, *d*) is about one-fortieth of an inch long and about half as wide. In color it is bright lemon yellow to orange. Its surface, as viewed under a high-power microscope, is finely sculptured, arranged in hexagonal pits (Fig. 3, *e*).

The larva (Fig. 3, *b*) is a very slender, white, wormlike creature, with dark-brown head and anal plate and lighter brown thoracic plate. When fully matured its length is about three-tenths of an inch, this being about ten times its width. It is provided in front with three pairs of thoracic or true legs, and behind with an anal proleg (hind false-leg). Figure 4 shows the head and thoracic plate (*a*), a true leg (*b*), and the anal proleg and anal plate in profile (*c*).

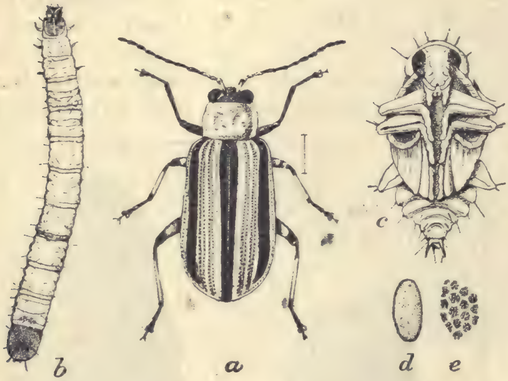

FIG. 3.

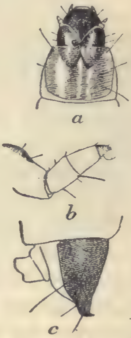

FIG. 4.

FIG. 3.—Striped cucumber beetle: *a*, Beetle; *b*, larva; *c*, pupa; *d*, egg; *e*, sculpture of egg. *a*, *b*, *c*, Much enlarged; *d*, more enlarged; *e*, highly magnified.

FIG. 4.—Striped cucumber beetle: *a*, Head of larva; *b*, leg of same; *c*, last segment from side, showing hind false-leg. All greatly enlarged.

The pupa (Fig. 3, *c*) is of nearly the same color as the larva and its surface is sparsely beset with long spinelike hairs, those on the upper surface or back arising from small but prominent hair-bearing warts.

WHERE IT OCCURS.

The striped cucumber beetle is native to this country and inhabits all parts of the United States east of the Rocky Mountains from Canada to Mexico. The approximate distribution is shown in the accompanying map (Fig. 5).

FOOD PLANTS.

The striped cucumber beetle is by far more common and more destructive than any other cucurbit pest with which the farmer and gardener have to deal. Hubbard and marrow squashes are its favorite food plants; cucumbers and muskmelons are most severely injured, while pumpkins, gourds, summer squashes, watermelons, and chayotes are also frequently damaged.

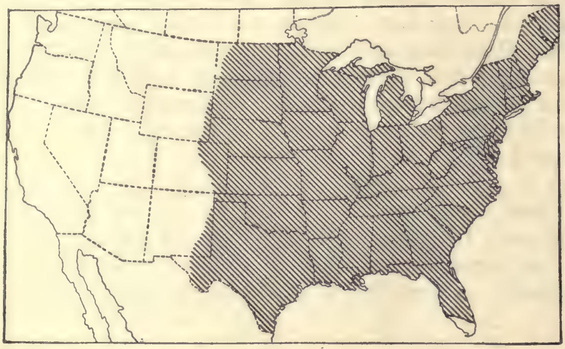

FIG. 5.—Map showing approximate distribution of the striped cucumber beetle.

It is not alone in the field and garden that this insect is troublesome, since serious injury is often done in greenhouses by both beetles and larvæ.

So far as known, the larvæ are restricted in their food to cucurbits, but the beetles attack other vegetation. Among these, beans are favorites, the beetles often congregating in numbers upon them, killing the leaves and rendering the pods so unsightly that they are unmarketable. Peas, ripe apples, apple blossoms, and the leaves, silk, pollen, and unripe kernels of corn are also attacked.

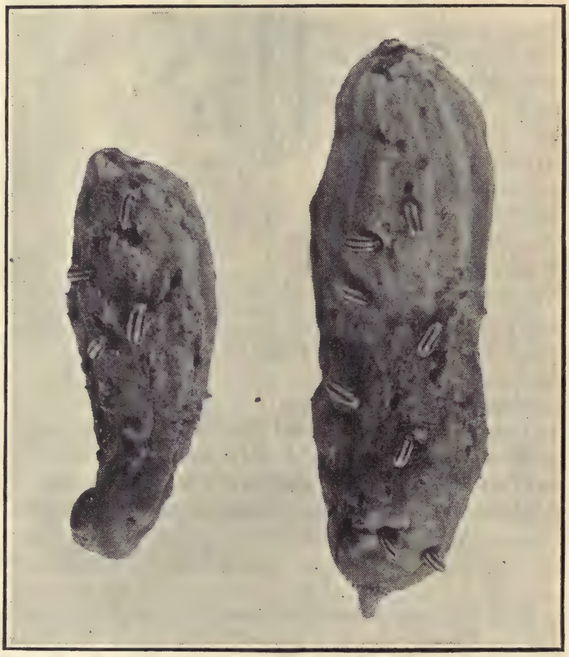

FIG. 6.—Striped cucumber beetles feeding on cucumbers after frost has killed the foliage. Natural size.

The beetles naturally are flower feeders and may be found on the large blossoms of the squash and pumpkin as long as they are in bloom. Notwithstanding this, they eat nearly every other portion of a plant, and frequently cause injury to cucurbits by gnawing the rind of the fruit, thus rendering it unfit for market. (See Figs. 6 and 7.)

Among wild plants the beetles are partial to the flowers of goldenrod, aster, and sunflower, devouring the colored portions, stamens, pistils, and ray flowers. In the spring they frequent the young plants of aster[3], goldenrod[4], and great ragweed,[5] and the flowers of chokeberry, Juneberry, cherry, and related plants. They feed freely on the prickly cucumber or wild balsam apple,[6] a plant cultivated for ornament and shade. Where observed in the District of Columbia, Maryland, Virginia, Iowa, Indiana, and Wisconsin the beetles make their first appearance on these plants during May and early June.

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[3] Especially *Aster puniceus*. [4] Particularly *Solidago altissima*. [5] *Ambrosia trifida*.

LIFE HISTORY AND HABITS.

The female beetles lay their eggs, either singly or in groups, in the soil about the roots and stems, frequently placing them in cracks and crevices. The number deposited by a single beetle varies, 1,457 being the highest number observed and between 400 and 500 the average. The eggs hatch in 1 to 2 weeks, the egg period, like all others subject to temperature, being shorter when the weather is warm. The larval life is passed in earth that is somewhat moist, about the base of the stalks, and larvæ may be found within the stems and on the fruit where these come in contact with the earth. This period lasts from 2 to 5 or 6 weeks. Hence there is an active stage of this duration in which the larvæ working in numbers have ample time for injuring the roots and stems.

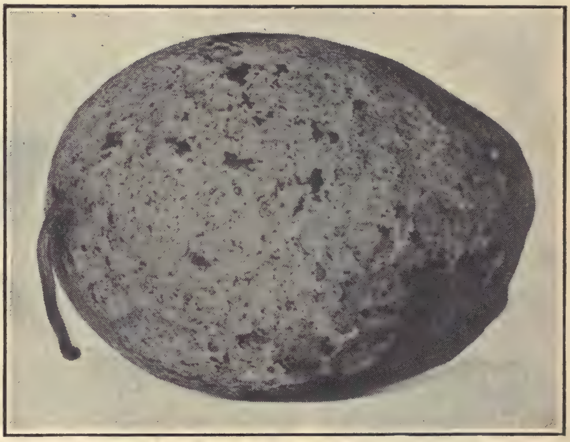

FIG. 7.—Ripe watermelon injured by striped cucumber beetle.

When full grown, the larva contracts and becomes much stouter. This is a preliminary period before the change to pupa and lasts from 2 to 5 days. The pupal period ranges from 5 to 8 days in warm weather to 2 weeks when it is colder.

Adults of the first generation begin to develop as early as the first week in July and continue to appear for several weeks thereafter. The overwintered beetles begin to die toward the end of July, so that there is some overlapping of the two generations.

The entire life cycle covers from 5 or 6 to 8 weeks, but in southern Texas it may be passed in less than 4 weeks. In the District of Columbia it occupies about 6 weeks.

NUMBER OF GENERATIONS.

Only one generation of the striped cucumber beetle annually has been observed in the more northern States. Farther south there are probably two or, exceptionally, three generations, and in southern Texas there may be even four. In the Middle Atlantic States newly transformed beetles occur from the second week in July until the first week in October.

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[6] (*Echinocystis*) *Micrampelis lobata.*

HIBERNATION.

Toward the end of the season, during September and October, in the principal trucking regions, the beetles congregate under the vines and prostrate portions of plants, withered leaves, and abandoned fruits of cucumber, melons, squash, and other cucurbits, hundreds sometimes gathering on a single fruit. Frequently they assemble in great numbers and eat off the rinds of the tender fruits. (See Fig. 6.) They also attack beans and destroy their value for market. After feeding freely, they seek various places of shelter.

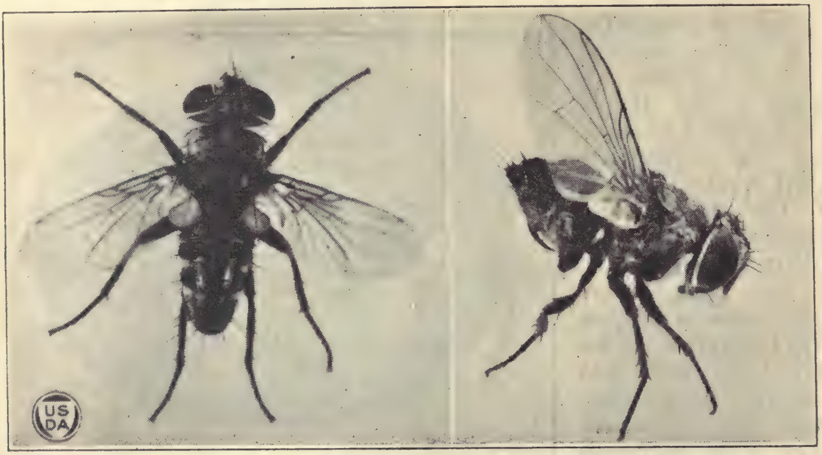

FIG. 8.—Back and side view of a fly parasite of adult striped cucumber beetle.

During the first cold nights of October in the District of Columbia the beetles begin to disappear, although hibernation may commence earlier. Just when this usually takes place, and where, has not been determined definitely; but, judging from the fact that the beetles are first seen on aster, goldenrod, and great ragweed along river bottoms, it seems probable that they hibernate in locations where these plants abound.

NATURAL ENEMIES.

The striped cucumber beetle has at least two important insect enemies, and several others have been observed. Adults are frequently destroyed by two kinds of parasitic tachina flies of similar habits, which develop within the abdomen of the host, whence they escape as flies. The first of these[7] has been known for many years and is widely distributed. The second[8] (Fig. 8) closely resembles the former and has been detected and described more recently.

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[7] *Celatoria diabroticae* Shimer.

[8] *Chaetophleps setosa* Coq.

Four kinds of predatory bugs[9] have been observed destroying the beetles. The bug inserts its beak in a vulnerable spot and kills the beetle by injecting a poisonous fluid and by sapping its life blood.

A common kind of ground-beetle[10] has been repeatedly observed destroying the striped cucumber beetle in Indiana, but is not an important factor in holding this pest in check. The same statement may be made of the Carolina mantis.[11]

Another enemy, a mite,[12] develops frequently when plants attacked are grown under glass, especially in cold frames. These mites when abundant fasten themselves to the body of the beetle, rendering locomotion difficult, if not impossible. Two parasitic fungi destroy this insect.[13] The former attacks the beetles; the latter, the larvæ. The beetles are also infested by parasitic worms called nemas.[14]

A number of bird enemies are known to feed upon the striped cucumber beetle. Among these are the nighthawk, phœbe, wood pewee, yellow-bellied flycatcher, gray flycatcher, least flycatcher, red-winged blackbird, starling, chewink, rose-breasted grosbeak, black-headed grosbeak, Carolina wren, hermit thrush, robin, and bluebird.

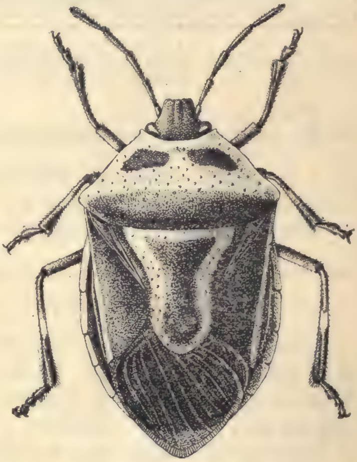

FIG. 9.—Double-eyed assassin bug, a predacious enemy of the striped cucumber beetle. Much enlarged.

METHODS OF CONTROL.

Direct applications of stomach poisons such as the arsenicals will destroy the beetles when they occur in moderate numbers, but have not proved entirely effective when they are very abundant; hence, recourse must be had to preventives, deterrent or contact poisons, and cultural methods.

Since the larvæ live in the roots and main stems, principally underground, it is difficult if not impossible to destroy them by any insecticide or other substance which would not at the same time injure the plants.

COVERING YOUNG PLANTS.

As a preventive of injury to young plants in the home garden early in the season, coverings are used. Barrel hoops cut in half, covered with screen wire, and put in the ground, may be used to protect the plants until they begin to run. Two strong wires bent in the form of croquet arches can be used for this purpose. The frame is covered with gauze or similar material of close mesh, so that the beetles can not work through it, and is held in place by earth packed about the edges to prevent the beetles from getting under it. Dish covers of wire gauze, such as are used for the protection of food from house flies (Fig. 10), serve the same purpose. When removed from the field they should be stored in a dry place, otherwise the gauze soon rusts.

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[9] *Sinea diadema* Fab., *Perillus bioculatus* Fab. (fig. 9), *Podisus maculiventris* Say, and *Nabis ferus* L.

[10] *Pterostichus lucublandus* Say.

[11] *Stagmomantis carolina* Johann.

[12] *Uropoda* sp.

[13] *Metarrhizium anisopliae* Metsch. and *Beauveria globulifera* Pic.

[14] *Howardula benigna* Cobb has been observed to have this habit.

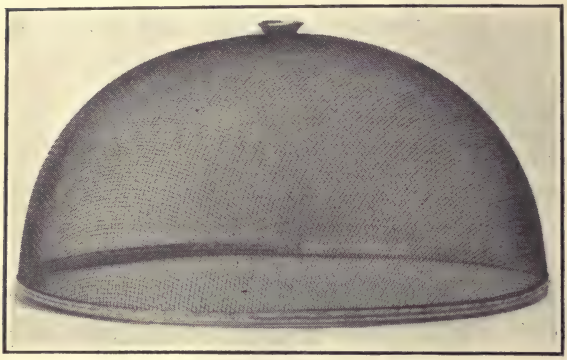

FIG. 10.—Wire cover for protecting plants against the striped cucumber beetle.

The forms of covering just advised appear to be the ones most easily prepared, most available, and most serviceable.

It is an absolute necessity that the covering employed fit tightly to the ground at every point to prevent the beetles from burrowing underneath.

PLANTING AN EXCESS OF SEED.

Another preventive consists in planting an excess of seed. By this method attack will be less concentrated and severe, and after the first danger period is passed the plants in each hill can be thinned out to the desired number.

A method which has yielded good results in some regions consists in planting the seeds in squares, one each week, as shown in the diagram. Frequently the first plant (1) is killed, and this may be the fate of the second (2), and sometimes even of the third (3). As long as the insects are seen they are poisoned, and this is continued until a stand of plants is obtained, as it is seldom that all four plantings are destroyed.

1	2
3	4

DUSTING WITH NICOTINE DUST.

Nicotine dust, a mixture of nicotine sulphate (liquid), hydrated lime, and a carrier, preferably kaolin or china clay, has been more successful in effecting control of the striped cucumber beetle than any other remedy thus far tested by the Bureau of Entomology. This dust may be prepared by the grower, and may contain any necessary proportion of nicotine.

FORMULAS TO USE.

For the control of the striped cucumber beetle, a dust containing 1.6 per cent of nicotine or its equivalent (4 per cent of nicotine sulphate containing 40 per cent nicotine) is effective. For the preparation of nicotine dust of this strength, either of the following formulas may be used, depending upon the amount required:

To make 100 pounds for field use:		
First formula—		
Hydrated lime	pounds	96
Nicotine sulphate, containing 40 per cent nicotine	do	4
Second formula—		
Kaolin	do	72
Lime	do	24
Nicotine sulphate, containing 40 per cent nicotine	do	4
To make 12½ pounds for use in gardens:		
First formula—		
Hydrated lime	do	12
Nicotine sulphate, containing 40 per cent nicotine	ounces	8
Second formula—		
Kaolin	pounds	9
Lime	do	3
Nicotine sulphate, containing 40 per cent nicotine	ounces	8

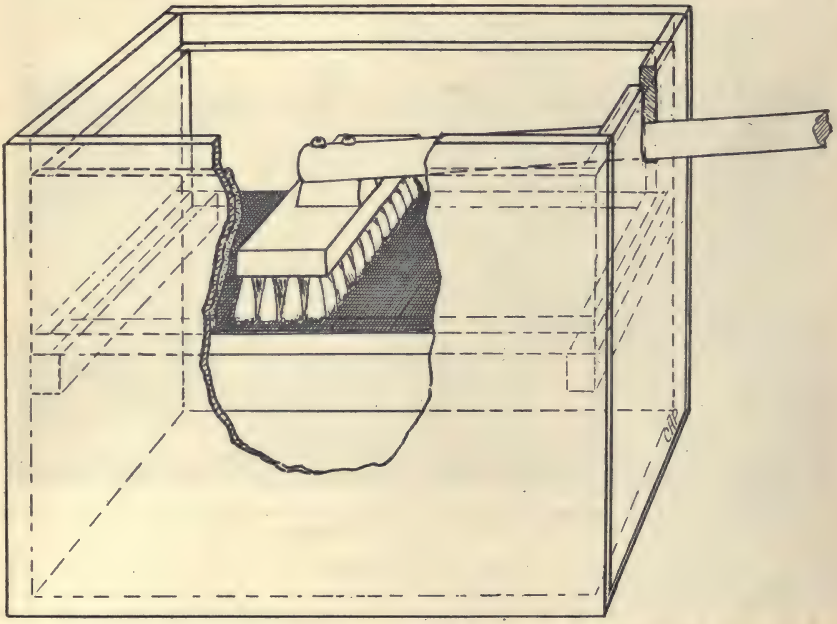

FIG. 11.—A mixer for use in the preparation of small quantities of nicotine dust. (White.)

PREPARING THE DUST.

In the preparation of the dust a thorough mixture of the nicotine sulphate with the carrier is essential. A convenient way of securing good results in preparing small quantities is to sprinkle the nicotine sulphate into the dust from a fruit jar with a perforated metal cap, at the same time stirring constantly. The resulting mixture, before use, should be resifted three or more times, with the aid of a brush, through a sieve having at least 20 meshes to the linear inch.

A very satisfactory and simple method of mixing the dust consists in the use of a box with a loose cover in which a sieve is placed and an ordinary floor brush with a handle is attached (Fig. 11). A slot is cut in the side of the box so as to allow operation of the brush with the cover on. The cover to a large extent prevents the escape of the dust during the mixing process, and consequent inconvenience to the operator.

The dimensions of a box in which 12½ pounds of the dust can be conveniently mixed are as follows: Length, 15 inches; width, 10 inches; depth, 12 inches.

The sieve is constructed of brass screen, 20 meshes to the inch, tacked to a frame 4 inches deep.

The sieve fits snugly inside of the box and rests on a strip 5½ inches from the upper edge of the box.

The brush is an ordinary floor brush with edge trimmed off so that the corners and edges of the sieve may be reached.

The handle, 20 inches long, attached at right angles to the brush, is so constructed that the brush will rest in a level position over the entire length of the sieve and that the end of the handle will come through a slot in the upper end of the box.[15]

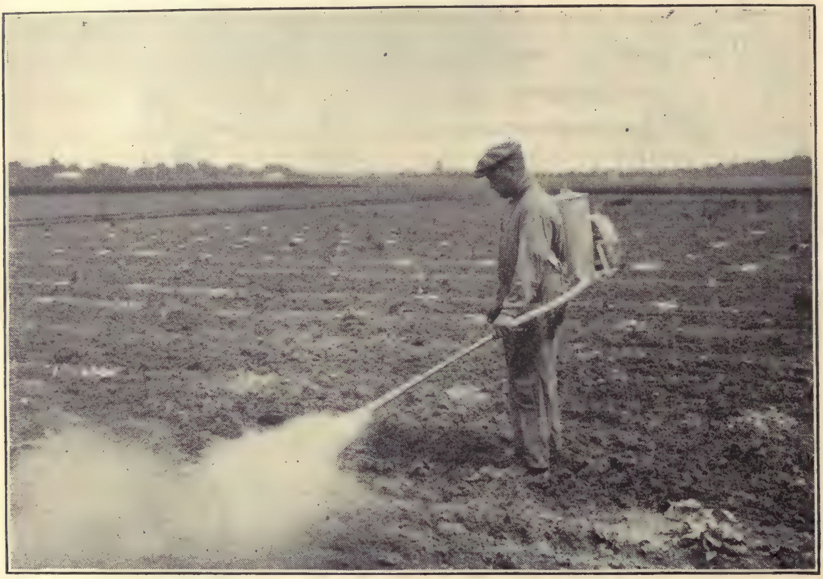

Fig. 12.—A good type of knapsack bellows duster to use in control of the striped cucumber beetle. (White.)

DUSTERS TO USE.

For the application of this dust, the most effective machine for small areas is of the knapsack bellows type (Fig. 12), and the best application is made, as far as results are concerned, by applying it thick enough to form a good covering on the plants and on the surface of the ground about the base. The dust may also be applied by means of a cheese-cloth sack (Fig. 13), held over the infested plants and the dust jarred therefrom as the operator passes up and down the rows.

HOW TO APPLY THE DUST.

One-fourth to one-half ounce to the hill is sufficient for one application. It must be applied so that the plant will be well covered, and the application should be made as soon as plants appear above ground, since the insect makes its first appearance suddenly, frequently in large numbers, and serious damage may result if the early application is neglected. Later applications are necessary in case of unusual abundance of the beetles or of adverse atmospheric conditions, such as wet weather. The plants and the soil at their bases must be kept well covered until after all danger of injury is passed In the vicinity of the District of Columbia this period is normally about three weeks, which will hold for other regions of similar climate.

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[15] White, W. H., Nicotine Dust for Control of the Striped Cucumber Beetle. (A Preliminary Report.) Department Circular 224, U. S. Dept. of Agriculture, p. 8. 1922.

ACTION OF NICOTINE DUST.

The nicotine dust acts both as a repellent and as a contact insecticide, and, properly applied, drives the beetles from the cracks in the soil about the bases of the plants where they rest and feed, and more or less completely coats their bodies, thus preventing them from escaping by flight, or disables or kills them after they have flown only a short distance. If applied in time the nicotine dust affords practically complete protection to young cucurbits against the striped cucumber beetle.

SPRAYING WITH ARSENATE OF LEAD.

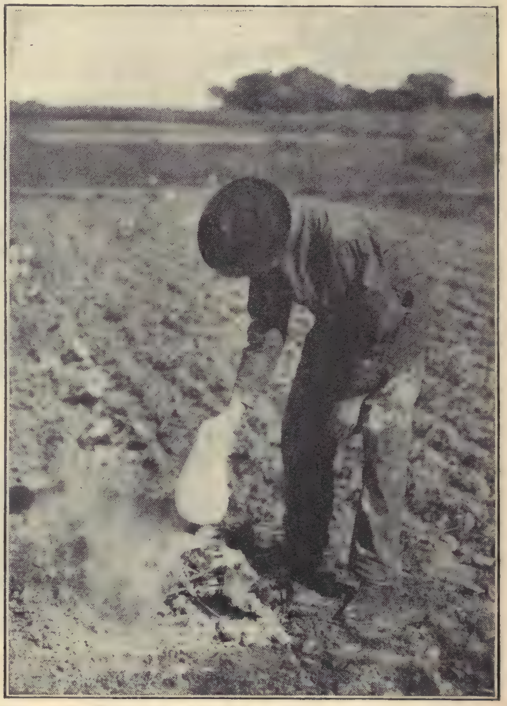

FIG. 13.—Dusting cucurbits with a cheese-cloth bag for control of the striped cucumber beetle. (White.)

Lead arsenate has been tested against the striped cucumber beetle under different local and other conditions, and has proved effective. It adheres to the plants better than Paris green; hence it is more useful where rains occur at the time of application. Where cucumbers are transplanted, tests should be continued as to the value of insecticides and fungicides combined, and of lead arsenate alone, as a dip for the plants before setting them out. It should be used at the weaker strength at first, and afterwards, if found desirable, at a greater strength; not, however, in excess of 2 pounds (dry or powder) in 25 gallons of water.

It is an efficient protective and injures the plants of cucumber and squash less than any other of several arsenical preparations tried. A spray of 1½ pounds of the dry arsenical to 50 gallons of water has proved as successful as one of 6 pounds to 50 gallons.

In connection with lead-arsenate sprays the employment of trap crops is advisable (see p. 14). After the plants of the main crop begin to run, it is advisable to spray them with Bordeaux mixture, prepared according to the 4–4–50 formula.

Lead arsenate has the following advantages over Paris green: (1) It contains less soluble arsenic and therefore is less harmful to growing plants and when applied properly at the correct strength does not scorch them; (2) it adheres more strongly to the foliage; (3) it leaves a white coating on the foliage, so that its presence or absence can be determined readily after spraying. When properly sprayed, treated plants have the appearance illustrated in Figure 14.

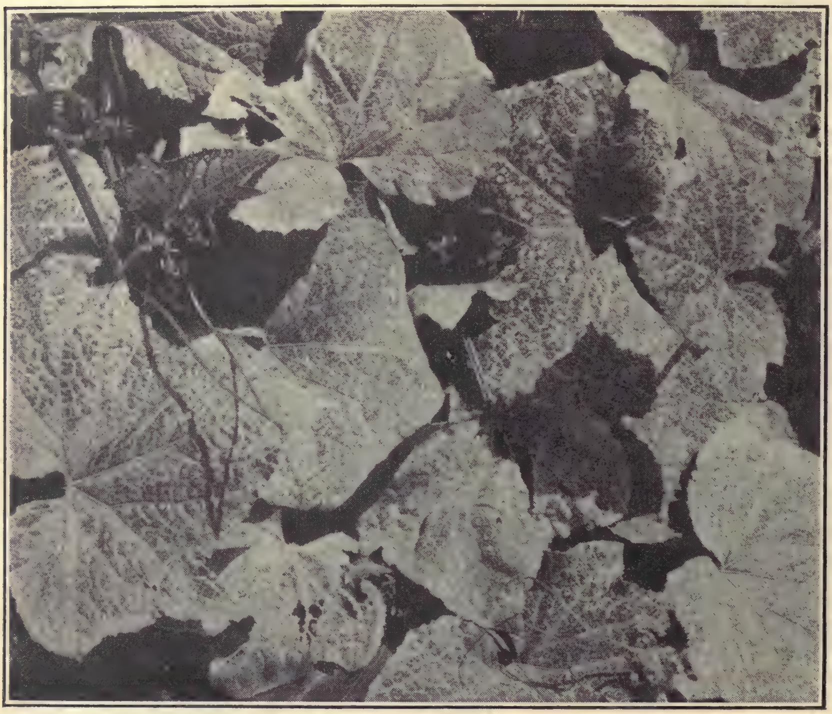

FIG. 14.—Cucumber leaves sprayed with Bordeaux-arsenate of lead for protection against the striped cucumber beetle.

The formula is as follows:

Arsenate of lead (powder)	pounds	3 or 1½
Water, or Bordeaux mixture (4–4–50 formula)	gallons	50 or 25

For small gardens use two-thirds of an ounce, or 10 level teaspoonfuls, of the powder to a gallon of water.

SPRAYING WITH BORDEAUX MIXTURE.

Bordeaux mixture, a combination of copper sulphate (bluestone) and stone lime or quicklime in solution, is a standard fungicide and a valuable repellent against certain leaf-feeding beetles. It also acts as a preventive of arsenical injury in spray mixtures. Its usefulness in the protection of cucumbers against the striped cucumber beetle warrants its employment in arsenical sprays against this pest. It may be prepared, according to the 4–4–50 formula, for home use as follows:

Provide two barrels, each of which should contain 25 gallons of water. Near the top of the water in one, suspend 25 pounds of copper sulphate in a burlap bag, allowing it to remain until dissolved. In the other slake an equal quantity of quicklime or stone lime. These form the stock solutions in such proportion that a gallon of liquid contains a pound of the chemical.

After thorough stirring, pour 2 gallons of the copper-sulphate solution and 10½ gallons of water into a wooden container. In a similar container mix 2 gallons of milk of lime with 10½ gallons of water. Pour these together, into the sprayer tank, through a brass wire strainer of not less than 18 meshes to the inch, thus making 25 gallons of Bordeaux mixture.

DIRECTIONS FOR SPRAYING.

Two or three sprayings ordinarily suffice for the overwintered beetles, and about the same number should be employed for the first new generation. One or two sprayings for the second generation, where it appears, also should be given. The first spray should be applied **as soon as the plants come up,** and the others at intervals of about a week, and just as the beetles of the first new brood appear and those of the second.

Applications of all poisonous preparations must be repeated when rainfall necessitates their renewal, until the plants have obtained a good start or the insects have dispersed. Arsenicals alone are not generally to be relied upon when the beetles are exceedingly numerous. One reason for this is that the beetles avoid the poisoned leaves and attack new growth or parts of plants which have not been covered completely by the spray mixture.

For success with any arsenical, every part of the plant must be coated—the upper and lower surfaces of the leaves and, above all, the vines and stalks, especially at the base—because when the beetles are abundant their feeding has the effect of girdling the plants near the base, even an inch under the surface of the ground.

In case Bordeaux mixture is sprayed on the plants as a protection against fungous diseases, lead arsenate should be added to protect the plants against leaf-eating insects, according to the formula given on page 12.

SPRAYERS TO USE.

For spraying against the striped cucumber beetle a compressed-air sprayer of about 3 or 4 gallons capacity (see Fig. 15) is considered the best for use in small gardens or in patches of from one-half acre to 2 acres, and is suitable even in somewhat larger fields, where labor is abundant and cheap. For larger fields, however, sprayers of the wheelbarrow or barrel type, handled by two men, are preferable. The method of applying the arsenical with a wheelbarrow sprayer is shown in Figure 16.

DUSTING WITH DRY ARSENICALS.

Lead arsenate and other arsenicals, alone or mixed with plaster or lime dust in the proportion of 1:10 to 1:25 by weight, and dusted over the plants, effectually protect them in many cases. They are no more effective than a spray, but may be employed more quickly and where water is not readily accessible.

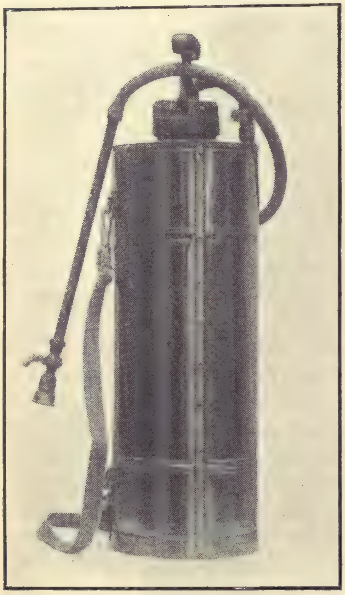

Fig. 15.—Compressed-air sprayer standing upright, showing hose, nozzle, and other attachments.

STIMULATING GROWTH AND KEEPING PLANTS IN CONDITION.

Injury to crops may be lessened by stimulating growth through generous applications of manure or commercial fertilizers and by frequent cultivation, which help the plants to outgrow attack. In parts of the South fish scrap is used as a fertilizer and is considered by many growers a useful deterrent of this and other insects attacking cucurbits. Frequent watering of the plants, by irrigation or with a cart or hose, is of great value, especially during dry weather, when they are seen to be wilting.

The plants should be examined carefully from time to time and kept free from the twelve-spotted cucumber beetle,[16] melon aphis,[17] squash-vine borer,[18] and other insects, since the aggregate injury to the vines by these pests renders the plants much more likely to succumb to the attack of the cucumber beetle on the foliage and of its larvæ at the roots.

CLEAN CULTURE AND USE OF TRAP PLANTS.

Injury from this as well as other cucurbit insects can be prevented largely by close attention to clean methods of cultivation. As soon as a crop is harvested the remnants should be raked into piles, covered with straw or other inflammable material, and burned. It is advisable, however, to leave standing here and there throughout the fields a few plants, such as those that might be desired for seed, upon which the insects that have not been reached by the fire may concentrate. Here the beetles can be easily destroyed with kerosene or a plumber's torch. As traps for the last generation, plant later or use later varieties.

---

[16] *Diabrotica 12-punctata* Fab. [17] *Aphis gossypii* Glov. [18] *Melittia satyriniformis* Hübn.

Late beans attract the beetles after the cucurbit crop has been made. The cooperation of cucurbit growers in the destruction of the fall brood of beetles would accomplish much in a few years, at least in some regions.

Any early squash may be planted as an early trap crop. Gourds planted in the vicinity of late cucumbers and melons act successfully as traps when the beetles are abundant. Pumpkins and squashes, being more hardy than other cucurbits, are especially serviceable for this purpose, as they withstand insect attack better. As an example of the attractiveness of these traps, about 50,000 beetles were collected for experimental purposes from such crops in a few days at the Bureau of Entomology station in Wisconsin.

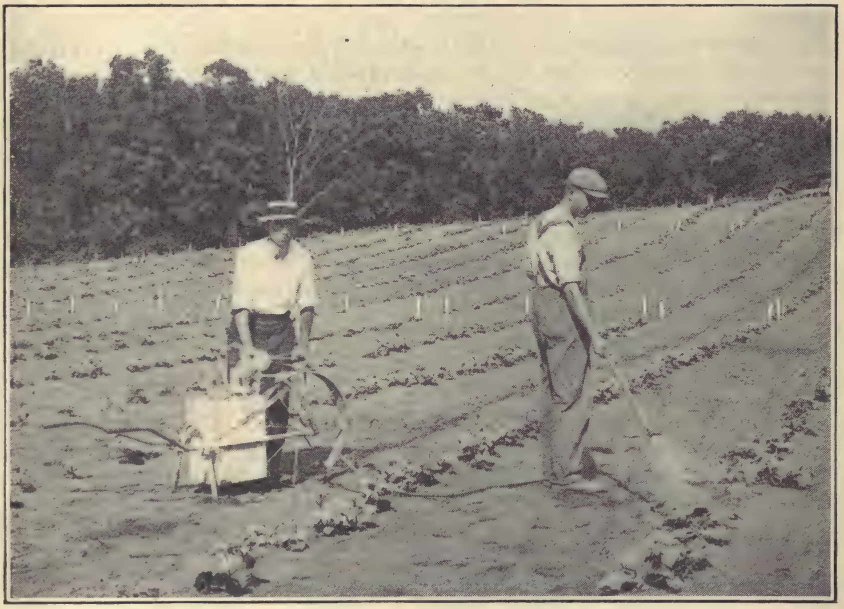

FIG. 16.—Spraying cucumbers with Bordeaux-arsenate of lead mixture by means of wheelbarrow sprayer.

INEFFECTIVE AND DOUBTFUL REMEDIES.

Pyrethrum insect powder, while fairly successful, is too expensive for use on a large scale. Naphthalene, in the form of flakes or camphor balls, as a deterrent is prohibitive for the same reason. Land plaster or gypsum and air-slaked lime saturated with kerosene or turpentine have been used as repellents but have never been claimed as of specific value. Dusting with air-slaked lime is in the same category. Such substances as charcoal, soot, road dust, saltpeter, and cow manure are not effective as repellents, and hellebore is not a useful insecticide against this beetle. Transplanting from frames or hothouses, while theoretically of value in establishing the plants so as to get ahead of the beetle, is not usually successful.

Zinc arsenite and calcium arsenate have not proved as desirable as lead arsenate.

SUMMARY OF CONTROL MEASURES.

The control measures which have given the greatest promise of success against the striped cucumber beetle are preventives, repellents, farm practice, and the use of insecticides. These may be summarized as follows:

In small gardens protect young and choice plants with coverings. These are useful only when the greatest care is observed to make them tight enough to keep out the beetles.

Plant an excess of seed, to distribute attack. This should always be done.

At the first appearance of the beetle apply nicotine dust containing 4 per cent nicotine sulphate by means of a knapsack bellows duster or a cheesecloth sack, with special attention to hitting the insects.

While the last-mentioned remedy is the best known direct method, additional experiments are desirable on spraying with lead arsenate, either alone or in combination with Bordeaux mixture, care being taken to cover every portion of infested plants, both surfaces of the leaves, the vines, and the stems.

Practice clean culture in connection with trap plants, such as beans, gourds, and early or late varieties of squash and pumpkin.

Stimulate the growth of plants by manures and other fertilizers, water them in drought and in hot weather, and keep them free from other insects and from disease.

Secure the active cooperation of neighboring growers of cucurbits in such of these methods as are possible. Community effort in the observance of these methods will in time undoubtedly lessen the danger of losses from this pest.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1323

The WHEAT STRAWWORM *and* ITS CONTROL

THE WHEAT STRAWWORM is distributed throughout the wheat-growing regions of the United States and ranks high in importance as an insect enemy of wheat, often destroying whole fields of spring wheat.

Two complete generations occur each year. The first generation kills outright each tiller of wheat which it infests. The second generation causes considerable loss in yield to winter wheat and kills outright the tillers of spring wheat which it attacks.

Several parasites and predacious enemies of this pest aid greatly in preventing continued losses, but can not be relied upon for complete and effective control.

The wheat strawworm attacks wheat only, and the first generation or spring form is wingless and is unable to travel great distances. It can therefore be controlled by planting wheat 65 to 75 yards from any wheat straw or stubble of the previous season. In addition to this, in the regions where spring wheat is grown, all volunteer wheat should be destroyed when this pest is abundant, to prevent reinfestation from this source.

Washington, D. C. May, 1923

THE WHEAT STRAWWORM[1] AND ITS CONTROL.

W. J. PHILLIPS, *Entomologist*, and F. W. POOS, *Assistant Entomologist, Cereal and Forage Insect Investigations, Bureau of Entomology.*

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ECONOMIC IMPORTANCE.

THROUGHOUT the wheat-growing States east of the Mississippi River the annual depredations of the wheat strawworm are ordinarily exceeded only by those of the Hessian fly[2] and the wheat jointworm,[3] and in certain areas it often exceeds either or both in destructiveness. In the wheat region of the Northwest also it is an important pest.

This insect occasions losses ranging from slight injury to total destruction of crops, depending upon its abundance. No serious outbreaks of the wheat strawworm have been recorded recently, although at present this species seems to be increasing rapidly, especially in some of the Eastern States. For this reason control measures should receive attention in order to reduce to a nominal amount the damage which may be caused by this pest.

WHEAT THE ONLY FOOD PLANT.

Unlike many important insect pests, the wheat strawworm apparently has only one food plant, namely, wheat. It has been observed to lay eggs in several other plants, such as barley, oats, rye, and several grasses, but in such cases the resulting larvæ or grubs were unable to complete their development. These facts greatly simplify the problem of control.

---

[1] *Harmolita grandis* Riley.
[2] *Phytophaga destructor* Say.
[3] *Harmolita tritici* Fitch.

DISTRIBUTION.

The wheat strawworm occurs throughout the more important wheat-growing regions of the United States. The accompanying map (Fig. 1) indicates the States from which it has been recorded by various observers of the Bureau of Entomology. There are a number of States from which no records of the occurrence of the wheat strawworm are available, but this insect probably occurs wherever wheat is grown.

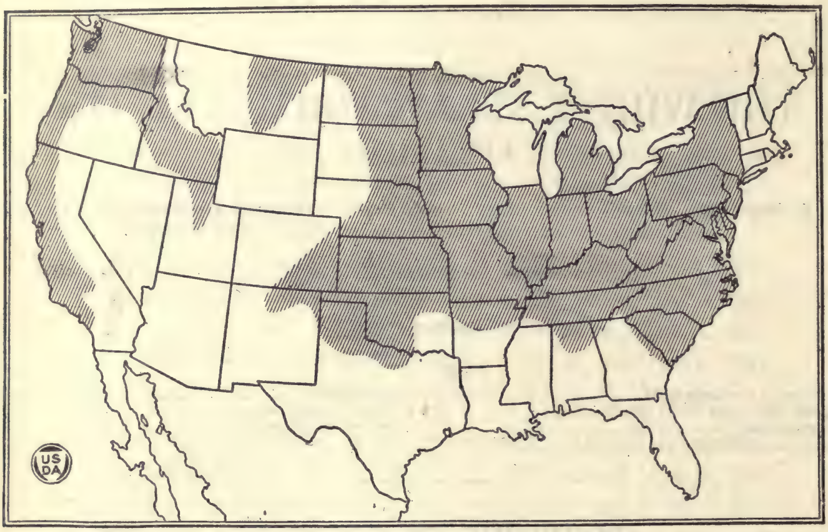

FIG. 1.—Map showing distribution of the wheat strawworm according to records of the Bureau of Entomology. The shaded area indicates the States from which occurrence has been reported.

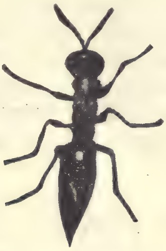

FIG. 2.—Wheat strawworm: Wingless adult female of spring form. Greatly enlarged.

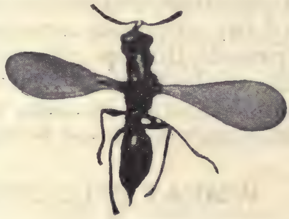

FIG. 3.—Wheat strawworm: Adult female of summer form. Greatly enlarged.

CHARACTER OF INJURY.

The wheat strawworm has two generations each year. The first generation is called the spring form[4] (Fig. 2) and the second generation is called the summer form[5] (Fig. 3). In the early spring the adult or parent insect of the first generation, or spring form, deposits its eggs (Fig. 4, *a*) in or near the embryonic wheat head (Fig. 5), when the young wheat plants extend only a few inches above the surface of the ground. The larva or grub develops within and near the base of the plant, subsequently destroying the tiller or the entire plant where this has not previously tillered. Thus all tillers infested by the spring form of this pest are prevented from producing any grain and become a total loss. The results of this injury are shown by the illustration on the title page, which shows the margin of a wheat field that was very badly infested by the spring form. Figure 6, from a photograph taken on the same date, shows plants about 60 yards from the infested margin of the same field shown on the title page. Note that the plants in Figure 6 are in full head as contrasted with those on the title page.

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[4] *Harmolita grandis,* form *minuta.*
[5] *Harmolita grandis,* form *grandis.*

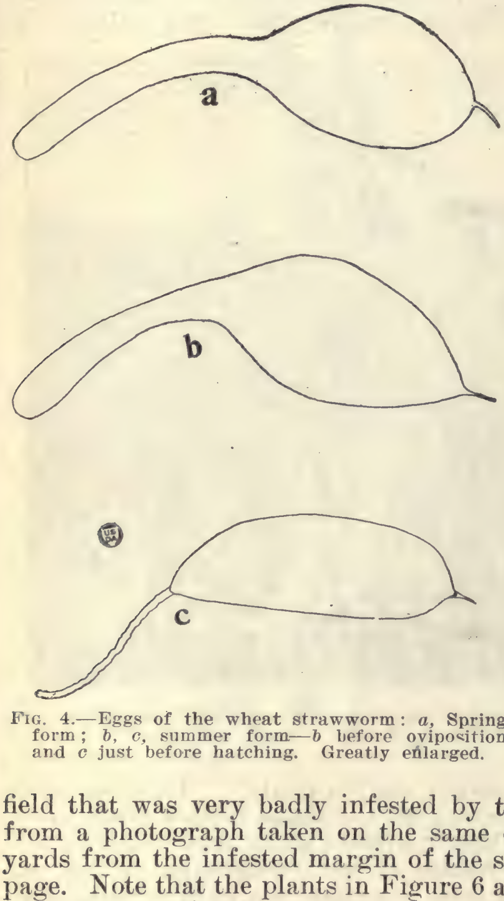

FIG. 4.—Eggs of the wheat strawworm: *a*, Spring form; *b*, *c*, summer form—*b* before oviposition and *c* just before hatching. Greatly enlarged.

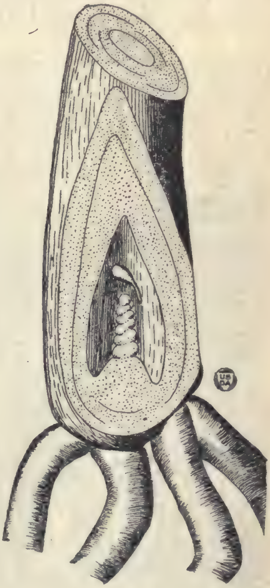

FIG. 5.—Diagrammatic drawing of young wheat plant, showing embryonic wheat head near which the eggs of the spring form of the strawworm are deposited. Note the egg within the envelope that surrounds the tender head. Slightly enlarged.

The infested tillers resemble those which are infested with the Hessian fly in that the central shoots do not develop and the leaves have the same characteristic dark green color. As the larva or grub completes its development, the tiller usually becomes bulblike at the point of infestation (see Figs. 7 and 8), where the larva occupies a cavity formed by its eating the embryonic heads. Later it transforms to the resting stage.

The injury to wheat caused by the second generation or summer form is not so severe as that caused by the spring form, except where spring wheat is attacked, when the injury and loss are similar to that caused by the spring form in winter wheat, as previously described. The summer form deposits its eggs (Fig. 4, *b* and *c*) in winter wheat just above the youngest and most succulent joints, usually after the plant has headed and is in bloom. The larva sucks the juice of the tender plant and develops rapidly in the center of the stem (Fig. 11), or sometimes in the walls of the stem before the straw has hardened. The stems of winter wheat are not killed and in fact show no external evidence of injury, but the effect produced by the insect is to reduce the yield of grain both in weight and in quality. This has been demonstrated clearly by collecting all the stems from a given area, separating the infested from the uninfested stems, and weighing the grain from each lot. The results of such weighings showed an average loss as high as 22 per cent, caused by the wheat strawworm. Where the yield of grain was estimated from heads of the same size collected from infested and uninfested stems, an average loss of 7 per cent was found.

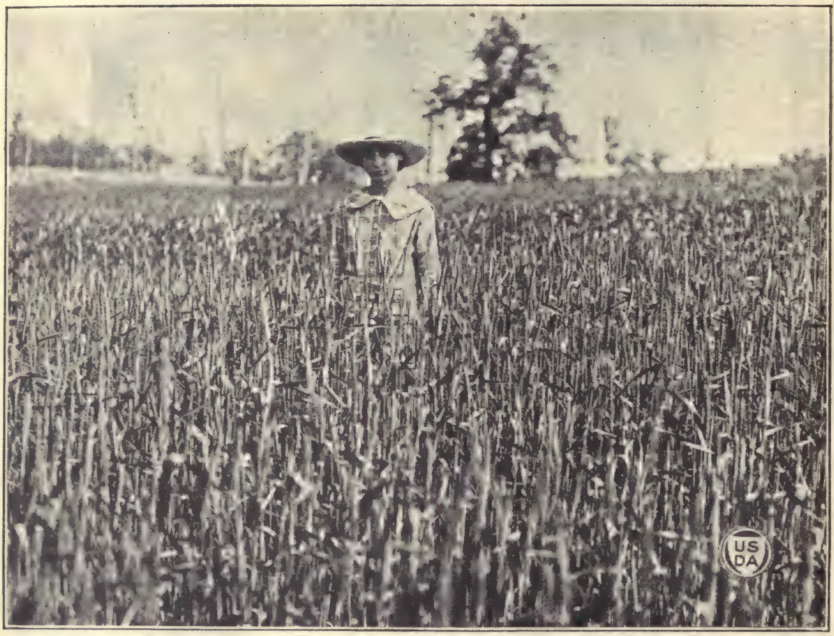

FIG. 6.—Normal wheat uninfested by the wheat strawworm. Compare this wheat with the infested wheat 60 yards away, shown on the title page. The two photographs were taken on the same day.

LIFE HISTORY.

The two generations of the wheat strawworm are designated as the spring form and the summer form, respectively, because of the fact that even though these forms comprise individuals of the same species, they do not resemble each other very closely. Each of these forms has four stages, namely, the adult or parent insect, the egg, the larva or grub, and the pupa or resting stage.

The adults of the spring form (Fig. 2) are minute, shiny black insects, closely resembling ants, and usually are without wings, or if wings be present they rarely are fully developed. The legs have light yellowish bands at the knees. In this form of the insect the winter is passed as a pupa (Fig. 12) in the wheat stubble or straw of the previous season. The adult of the spring form, which is practically always a female, emerges in March and April in the Eastern and Central States, while in Washington State emergence occurs in April, and in Arizona it takes place during the latter part of January and continues through February. The females of this generation deposit their eggs in young wheat plants, in or very near the embryonic wheat head (Fig. 5). The egg (Fig. 4, *a*) is white and nearly transparent, pear-shaped, and has a short, thick pedicel which is slightly curved. In about 10 days the larva hatches from the egg and totally destroys the embryonic head within the plant, usually causing a slight enlargement of the stem (Figs. 7 and 8) at the point

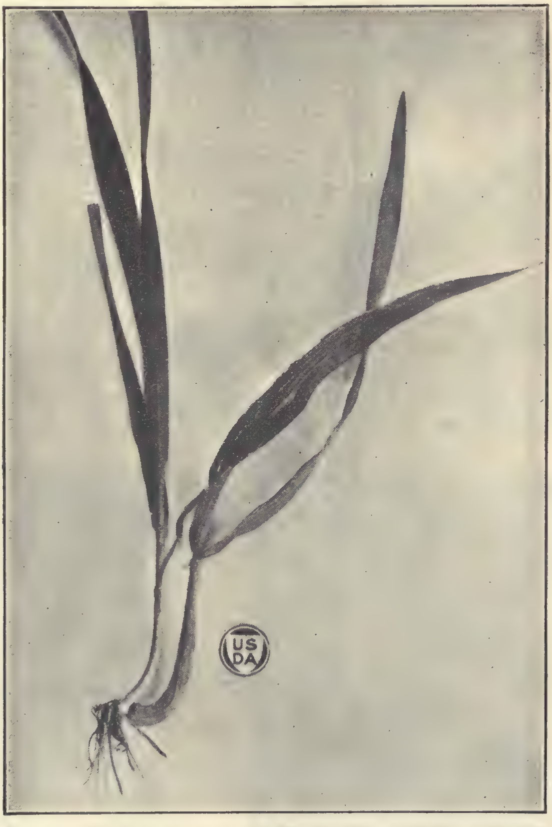

FIG. 7.—Young wheat plant showing healthy tiller at left, the tiller at right infested by the spring form of the wheat strawworm. Note the absence of the central shoot and the bulblike appearance of the infested culm near the base. About natural size.

of infestation. The cavity thus formed in the crown of the plant is occupied by the larva (Fig. 9) after it has completed its feeding. This larva becomes more robust than those of the summer form, perhaps because it feeds on the most nutritious part of the plant. It is of a light straw color, has brown jaws, and when full-grown is 0.17 inch (4.5 millimeters) long. Full growth is reached in about 27 days and the pupa or resting stage then begins (Fig. 10). At first the pupa is the same color as the larva, but later changes to a shiny jet black.

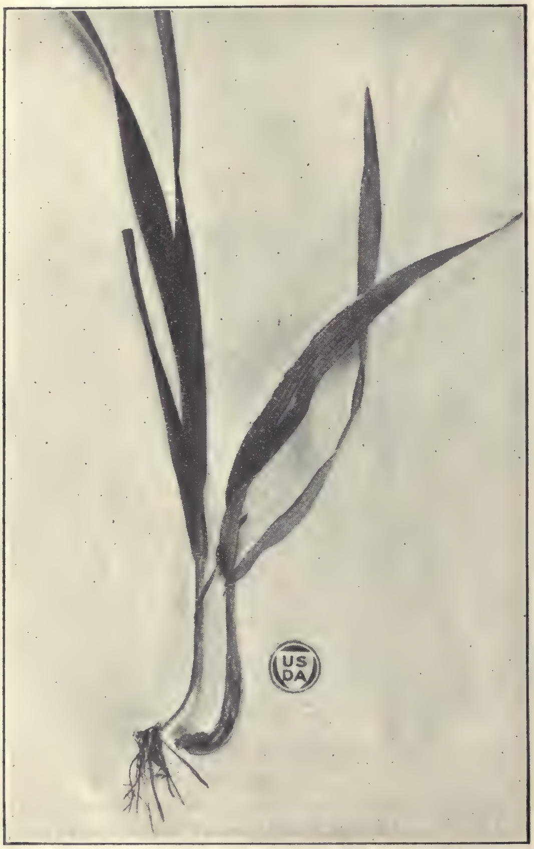

FIG. 8.—Same plant as shown in Figure 7, the infested tiller being split to show the wheat strawworm in the cavity it has formed by eating the embryonic wheat head. About natural size.

The pupa stage requires about 12 days, after which the fully developed adult of the summer form gnaws circular holes through the walls of the stem and comes out.

The adults of the summer form (Fig. 3) are much larger and more vigorous than those of the spring form. They have fully developed wings which they use to great advantage in dispersing throughout fields adjacent to their place of development. Apparently they are strong flyers and with the aid of favorable winds have been found to fly to fields at considerable distances from where they originated.

No males have been found among the adults of the summer form, and the females reproduce without mating. They emerge in May and June over most of the wheat-growing region, and deposit eggs (Fig. 4, *b* and *c*) singly in the growing wheat plants slightly above the joints, about the time winter wheat is coming into bloom. The two upper joints are usually preferred for oviposition, though every joint may be infested. Often the eggs are placed directly in the cavity of the stem or culm, but may be placed in the walls of the stem. The eggs hatch in from 5 to 5½ days. Normally but one larva is found at a joint. Where more than one larva is present one usually may be found in the center of the stem, just above the joint, and others in the walls. The larvæ lacerate the inner walls of the stems, where they suck the rich plant juices and develop rapidly, because they must attain full growth before the plant tissues have hardened. The full-grown larvæ of the summer form resemble in color those of the spring form and are long and slender and not so robust. They form neat cells within or near the joints (Fig. 11) and remain there

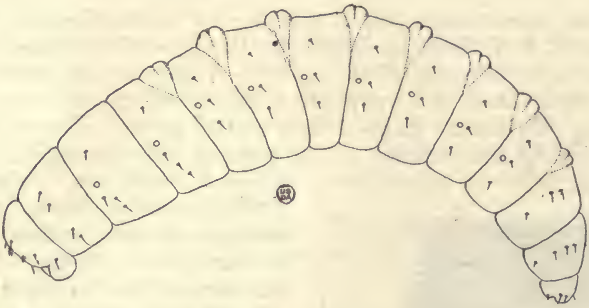
FIG. 9.—Full-grown larva of the spring form of the wheat strawworm. Greatly enlarged.

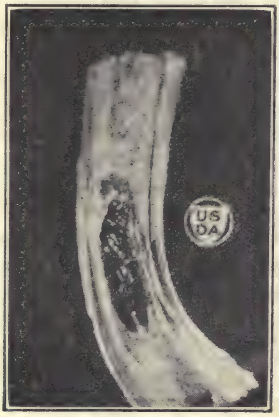
FIG. 10.—Pupa from which emerges the adult of the summer form of the wheat strawworm in the tiller of a young plant where it developed. Greatly enlarged.

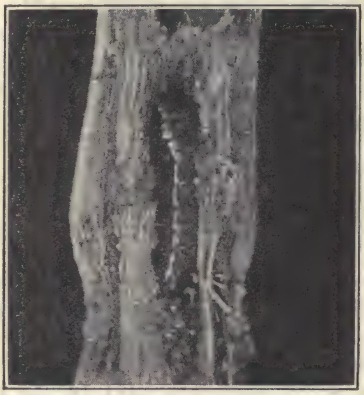
FIG. 11.—Full-grown larva of summer form of the wheat strawworm in its cell in the center of the wheat stem.

to enter the pupa or resting stage (Fig. 12) in the fall. No change occurs until early spring, when they develop to adults of the spring form and gnaw their way out to continue their life cycle.

NATURAL ENEMIES.

The wheat strawworm has a number of parasitic and predacious enemies, but it is difficult to determine their relative efficiency because of the wide distribution of this pest. A predacious enemy of considerable importance is a very small mite[6] which destroys the larva in the stem. This mite gains access to the larval cells which become ruptured during the process of harvesting and thrashing. Another reported predator is the larva of a small black and yellow beetle.[7] Unfortunately these predacious enemies do not confine themselves to the larva of the strawworm, but devour the beneficial parasites as well as the host.

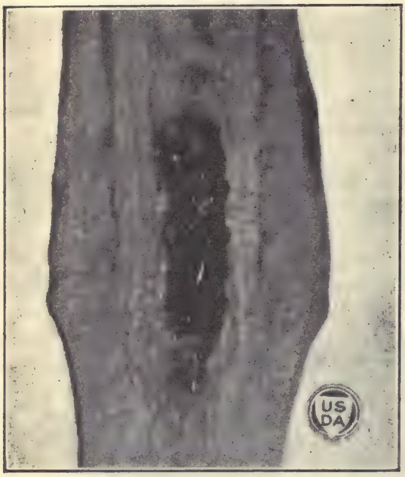

FIG. 12.—Pupa from which emerges the adult of the spring form of the wheat strawworm in its cell in old wheat straw. Note how each end of the cell is plugged with frass. The winter is passed in this stage.

Of the several parasites of the wheat strawworm, one of the most important is known scientifically as *Eupelmus allynii* French. Wheat stems collected in Virginia as early as June 21, in 1921, showed by dissection as high as 22 per cent of the stems parasitized by this species. This parasite is a small, slender, four-winged wasp with a somewhat brilliant greenish-black body and yellow legs. In the southern half of the United States it has as many as four or more generations each year.

Three parasites of importance[8] and similar in appearance have yellow abdomens and metallic-colored bodies. Each of these parasites has two or more generations each year.

Another parasite of importance[9] has five generations each year in the southern half of the United States. This species in the adult stage is bluish-black and in its life history is very similar to the parasites previously mentioned, except for the greater number of generations.

All of the parasites mentioned are minute four-winged wasps in the adult or parent stage and are about the same size as the adult of the strawworm. Unfortunately, when unassisted they can not be depended upon to control the wheat strawworm.

---

[6] *Pediculoides ventricosus* Newp.

[7] *Leptotrachelus dorsalis* Fab.

[8] *Ditropinotus aureoviridis* Crawford, *Merisus febriculosus* Girault, and *Eridontomerus isosomatis* Crawford.

[9] *Homoporus chalcidiphagus* Walsh.

CONTROL MEASURES.

The parasites and predacious enemies of the wheat strawworm are important factors in preventing continued serious losses which this pest might cause. Without these enemies of this pest, growing wheat for profit would be difficult unless effective methods of control were practiced to some extent.

The first generation or spring form of this pest is practically wingless and can not travel great distances to infest young wheat and thus continue the life cycle. Where wheat is planted adjoining wheat stubble or straw stacks of the previous season it has been found that the infestation caused by the spring form is greatest within 30 yards of the edge of the field which borders the old wheat straw. The writers have found, however, that the infestation at times may reach twice this distance, especially where the prevailing winds are favorable to the migration of the pest.

Where the wheat strawworm is troublesome an effective control, therefore, is to avoid growing wheat within 65 to 75 yards of wheat straw of the previous season.

In Virginia it has been found that wheat can safely follow wheat on the same land if all stubble is plowed under after harvest and the land sown to cowpeas, which in turn are disked into the soil in time to sow the wheat in the fall.

In regions where spring wheat is grown to the exclusion of winter wheat, volunteer plants furnish the only places in which the adults of the spring or wingless form, developing from pupæ overwintering in wheat straw or stubble of the previous year, can lay their eggs, the egg-laying period of this generation being finished before any spring-sown wheat is up. From these volunteer plants, therefore, if not destroyed, emerge the adults of the second generation or winged form, which, laying their eggs in the spring wheat, may cause considerable loss to the crop.

In localities where the wheat strawworm is injurious, wheat should not be top-dressed with manure containing unrotted straw which is infested by this species.

Straw stacks are a greater source of infestation to growing wheat by the wheat strawworm than is usually supposed. In communities where this pest is very abundant, volunteer wheat around the straw stacks should be destroyed by early spring before the first generation has developed.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1324

LAMB AND MUTTON AND THEIR USE IN THE DIET

LAMB AND MUTTON, like other meats, are nutritious and wholesome foods, and can often be used to advantage to increase the supply of fresh meats on the farm. This bulletin suggests good ways of preparing lamb and mutton for the table and of combining them with other materials of suitable flavor.

This bulletin supersedes Farmers' Bulletin 526, Mutton and Its Value in the Diet.

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LAMB AND MUTTON AND THEIR USE IN THE DIET.

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LAMB AND MUTTON have long been important foods in many parts of the world. The term "lamb" is usually applied to the flesh of a sheep less than a year old, while that of older animals is known as "mutton."

Mutton is a very popular meat in England, but in this country lamb is much preferred and in many retail markets mutton is not to be found. This one-sided demand is naturally one reason for the comparatively high prices charged for lamb.

Formerly much of the prejudice against mutton was probably due to the strong flavor of meat from old or carelessly slaughtered animals, but with more careful selection of animals for the market and the present improved methods of handling and storage there is little ground for such prejudice.

Many persons, especially children, dislike mutton, and even lamb, because of the peculiar texture of the fat, especially when it is cold. When the meat has been cooked by broiling or roasting the flavor as well as the texture of the fat is more agreeable. Since it is desirable that children form the habit of accepting without question any wholesome food, it will be quite worth the trouble required to serve the fat in such a way that they will not become prejudiced against the meat itself. Hot lamb or mutton should be served from a hot dish on hot plates, in order to prevent the fat from hardening too quickly, and it goes without saying that gravy should always be served from a hot dish.

The average cuts of lamb and mutton contain a somewhat higher percentage of fat than is found in beef, but because of the peculiar texture of this fat, especially when cold, perhaps less of it is actually eaten than in the case of beef. Nevertheless, it is quite likely that on the whole the lamb and mutton actually eaten have a larger percentage of fat and consequently a slightly higher fuel value than beef. As regards ease and thoroughness of digestion there is little if any difference between the two kinds of meat.

USE OF LAMB AND MUTTON ON THE FARM.

Few grown sheep weigh over 75 pounds when dressed, while dressed lambs range from 40 to 50 pounds in weight. The ease with which animals of this size can be slaughtered on the farm is shown in another bulletin of this series.[1] The fact that the carcass is small is an advantage, since there is not too much meat to be used while it is still in good condition. This makes the sheep a very desirable animal for use as part of the farm supply of fresh meat.

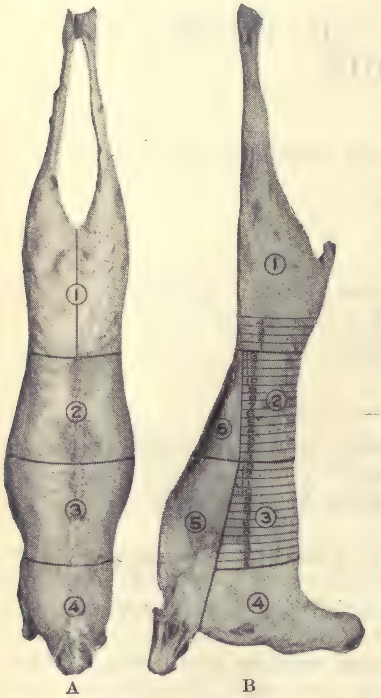

Fig. 1.—A, Wholesale cuts of lamb or mutton: (1) Legs, (2) loin, (3) hotel rack, (4) chuck; (1) and (2) together make the cut known as the saddle, (3) and (4) together make the forequarters or market rack. B, Retail cuts of lamb or mutton: (1) Legs, (2) loin, (3) hotel rack, (4) chuck, (5) breast, (6) flank.

Before a lamb or sheep is slaughtered on the farm it is well to consider the order in which the various parts will be used, also the methods that may be employed for keeping in good condition the cuts which will be needed later.

Unless good cold storage is available it will be better to divide the carcass into as few cuts as possible, thereby avoiding extra handling and the exposure of numerous freshly-cut surfaces. Certainly no fancy trade cuts, such as "crown roast" or the "French" trimming of the leg or chops, should be made unless one wants them for special occasions and the pieces are to be cooked at once.

Figure 1, A, shows the first cuts which might be made in a lamb carcass for farm use. These are the cuts usually known as wholesale cuts. Further divisions usually made by retailers are shown in Figure 1, B, where breast and fore shanks (5) are separated from the neck and shoulders (4) and from the rib chops or roast (3). The weights of these cuts from a 50-pound carcass would be about as follows:

Weights of different cuts of lamb.

	Pounds.
Legs, each	8.25
Whole loin, including flank	8.50
Ribs	6.00
Shoulders, including neck	11.75
Breast and shanks	7.25

Since obtaining fresh meat is the prime object of the home butchering, it should be the practice to begin to use the meat as soon as it is well cooled. The internal organs will probably be used first. The liver may be broiled with bacon, and the heart and tongue, eked out with the head or a piece of the flank, may be simmered for two or three hours and served either hot or cold. Dumplings are a much-liked addition to this dish. Any left-over boiled lamb or mutton is most excellent fried a light brown in a little butter as a supper or lunch dish. Of course, broiled chops and a leg or loin roast will be among the early treats in the way of fresh meat.

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[1] Farmers' Bul. 1172, Farm slaughtering and use of lamb and mutton.

METHODS FOR TEMPORARY PRESERVATION OF THE MEAT.

If the meat can not be used promptly methods of preservation should, of course, be employed without delay, since spoilage awaits no one's convenience.

In dry, clear weather, even in summer, a leg of lamb or mutton may be kept for days in good condition by hanging it from a sterilized hook where it will swing free in a current of air. The place must be screened completely from flies, but the screening must not touch the meat nor interfere with the free circulation of air. The dry film which forms on the surface of the meat is its protection against the inroads of bacteria.

Where there is a fairly cool storage place, stewed, braised, or boiled meat may be preserved for some time by sealing carefully under a thick layer of fat. The rather hard fat of lamb or mutton is especially satisfactory for use in this method, which is an adaptation of the well-known one of "frying down." The meat is seasoned and cooked as if it were to be used at once, but certain special precautions must be observed. No more meat should be stored in one container than can be used promptly, once it has been opened. To make sure that not only the meat but also the container in which it is to be stored is sterilized, it is well to cook the meat in the container itself. An enameled pan, or an earthenware jar or crock, will be found satisfactory, but a metal container should not be used. The meat should be placed in the container in such a way that it will be fairly well covered by the broth. If there is not enough fat to insure a thick layer over the top when the dish has cooled, more should be added in the cooking. When the meat is cooked the container should be set aside where it will not be disturbed until the fat has become solid over the top. In case the meat is found protruding through the fat in places, more fat, heated frying hot, should be poured over it. Store in a cool place in order to keep the fat solid. When the meat is to be served, remove the cold fat carefully and reheat the meat. It should be remembered that if the seal of fat is found to be broken the condition of the meat is to be questioned, as it would be in the case of canned meat in a "leaky" can.

Lamb and mutton, like other meats, may be satisfactorily canned at home. A steam-pressure cooker is frequently recommended for the purpose, especially in warm regions. Directions for the use of the pressure cooker are given in another publication of the department.[2]

As an aid in utilizing the odds and ends of trimmings from the carcass of lamb or mutton, the lean scraps may be ground fine, seasoned to taste, and made into a loaf or cooked as Hamburg steak. These preparations may be kept for some time after cooking by covering them with hot fat, using the precautions suggested above.

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[2] U. S. Dept. Agr., S. R. S. Doc. 80, Home canning of meats and sea foods with the steam-pressure canner.

To avoid monotony, the serving of the fresh lamb or mutton should be interrupted every few days by using such meats as poultry, ham, fresh or salt fish, or dried beef.

Preserving the meat by means of salt is effective, of course, but meat so treated is no longer " fresh " meat. However, circumstances may make it necessary to cure a cut or two in this way. In this case the following directions for dry-curing small quantities of meat, adapted from another bulletin[3] of the department, may be used:

DRY-CURED LAMB OR MUTTON.

Trim the pieces into shape and inspect each one carefully to see that all blood vessels are drained and clots of blood removed. For each 10 pounds of meat use a mixture of the following:

- 1½ cups salt.
- ¾ cup brown sugar.
- 1 tablespoon cayenne pepper.
- 2 tablespoons black pepper.
- 1 tablespoon saltpeter.

Rub the mixture over the meat, being careful to cover every portion. If necessary, more of the mixture may be rubbed onto the meat from time to time. Keep the pieces in a dry place free from flies or vermin. Wash and scrape the meat well before cooking to remove the excess of the preservatives used.

Smoked mutton, an old-fashioned form of cured meat, can be used like dried beef.

UTILIZATION OF THE FAT.

The fat which cooks out from lamb and mutton mixed with that from bacon or ham will be found to be satisfactory for many uses. Fats from the top of stews or broth or from the roasting pan may also be used as a savory fat in the seasoning of vegetables.

Where the excess fat from an entire carcass is to be disposed of, the leaf and other fine fats may be rendered and saved until these can be conveniently combined with lard in about equal proportions for use as shortening or in frying. The less desirable portions of fat trimming can be rendered, unsalted, for use where any heavy grease is needed.

The following method may be used for modifying the flavor of lamb or mutton fat: Mix two parts of lamb or mutton suet with one part of leaf fat of pork, grind the mixture fine, and heat in a double boiler with about half its weight of whole milk. By this method the fat is quickly released from the tissues and when strained and allowed to cool forms a cake on the surface of the liquid. This fat possesses little of the characteristic " mutton " odor or flavor.

Where lamb or mutton fat is used in making cream gravy both the texture and the flavor of the gravy are better if the flour used is browned lightly in the hot fat before the liquid is added. The addition of capers, or the liquid in which they have been bottled, chopped pickle, lemon juice, tomatoes, or currant jelly is suggested as improving the flavor of the gravy.

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[3] Farmers' Bul. 1172, Farm slaughtering and use of lamb and mutton.

REFUSE AND WASTE.

No matter whether a sheep is slaughtered in a packing plant or on the farm, only about 45 per cent of the live weight of the animal appears as dressed meat, and, after all the superfluous tallow—that is, the fat ordinarily removed before the cut is sold at retail—has been removed the remainder consists of about 19 per cent of bone and 81 per cent of edible material.

It is not possible to state exactly what the amount of waste in bone will be in any given retail cut because of variations in the size and grade of the carcass.

The following table showing the approximate percentage of bone in various cuts is based upon data obtained by weighings made of the cuts from a carcass of lamb of average size and grade. The corresponding cuts of mutton usually yield slightly higher percentages of edible material, owing to the fact that mutton carcasses are somewhat better filled out than lamb.

Approximate percentage of bone in various cuts of lamb after removal of superfluous tallow fat.

Name of cut.	Number of cut as shown in Fig. 1.	Approximate percentage of bone.	Approximate percentage of edible material.
Saddle (wholesale cut, excess fat removed)	Nos. 1 and 2, Fig. 1, A.	17.6	82.4
Market rack (wholesale cut)	Nos. 3 and 4, Fig. 1, A.	21.2	78.8
Leg (excess fat removed)	No. 1, Fig. 1, B	20.0	80.0
Loin (excess fat removed)	Nos. 2 and 6, Fig. 1, B.	12.3	87.7
Loin, roast, or chops (flank and excess fat removed)	No. 2, Fig. 1, B	15.2	84.8
Ribs, trimmed short (hotel rack)	No. 3, Fig. 1, B	18.3	81.7
Shoulder, including neck	No. 4, Fig. 1, B	21.1	78.9
Breast and fore shank	No. 5, Fig. 1, B	24.0	76.0

SELECTION AND USE OF THE MEAT.

The percentage of waste is of first importance, but is not the only point which is considered in selecting cuts of lamb and mutton. The color of the lean and the fat, the size of the bones, the general shape of the cuts should all be noted.

Good lamb or mutton will show a fairly complete covering of fat and the loin fat around the kidneys will be white and flaky. Other things being equal, there is less waste in cuts having moderate amounts of fat. The color of the lean of lamb is reddish pink, while the lean of mutton is darker. The loin or rib chops of lamb are not large, but they should show good full "eyes" of lean with a border of fat. Similar cuts of mutton should have the same general finish and, though larger than corresponding cuts of lamb, the bones of young mutton will still be fairly light in weight. The legs of both lamb and mutton should be plump without much length of shank.

Experience has shown that certain cuts are more tender and juicy than others, as well as easier to prepare and more attractive in appearance, and are for these reasons the first choice of most persons. In the carcasses of all meat animals the tender cuts are found along the back from behind the shoulders, including the ribs, loin, rump, and the upper portion of the hind legs. In the remainder of the carcass, that is, in the neck, forelegs, shoulders, and the hind shanks, are found muscles which have been more actively used by the animal and which contain comparatively large amounts of firm connective tissue. The heart is a striking example of muscle tissue hardened by constant use.

COOKING OF TENDER MEAT.

In cooking tender meat one general method is to be used. The chop or roast is first thoroughly seared on all sides and slightly browned by subjecting it to high heat. After this has been done the heat is reduced somewhat and the meat is cooked to the desired degree in its own juices.

The problem of broiling or roasting is to complete the cooking of the inner part of the cut without overcooking the surface. In the broiling of chops this is done by turning them frequently which allows for intermittent cooling of one surface while the other is exposed to the heat.

In roasting the hardening of the surface is lessened by basting with water or by covering the roaster after the meat is first browned, so that the confined steam accomplishes the basting.

COOKING OF THE TOUGHER CUTS.

Since it is the connective tissue which causes the comparative toughness, it is to this that the housekeeper must direct her attention. Either one of two methods may be used. The meat may be finely ground, thereby cutting the connective tissue into very small pieces, or it may be cooked in water until the connective tissue is softened.

In the preparation of ground meat it is well to put the meat through the grinder twice, using the fine blade. Ground meat should be cooked in the same way as any tender meat; that is, by first searing the surface well in order to prevent the escape of the juices, then reducing the heat to finish the cooking.

In the cooking of tough meat in water the connective tissue is gelatinized and so made soft, but in order to avoid cooking the meat to pieces the water should be kept simmering instead of boiling. By allowing enough time for the cooking to be done without hurrying, very satisfactory results may be obtained with meat that is quite unpromising. The same principle applies whether the meat is boiled, stewed, braised, or smothered.

The steam-pressure cooker is frequently used for tough cuts of meat, as in it the connective tissues are softened much more quickly than by ordinary cooking.

Notwithstanding the fact that the less tender cuts of meat are usually taken as a second choice, they furnish meat that is highly desirable both from the point of view of nutritive value and flavor. Also, the preparation of such meat is not difficult, provided it is properly understood and managed. This division of the carcass according to whether the meat is tender or comparatively tough suggests differences in the methods of cooking.

RECIPES.

The recipes given here for lamb and mutton are planned to include all the different cuts of the carcass and will be of help to a housekeeper who may wish to extend her choice of cuts beyond the stereotyped range of chops, roasts, and stews.

LEG, LOIN, OR RIB ROASTS.

The leg, loin, and rib are the cuts of lamb or mutton best suited for roasting. See that the meat is clean, but avoid washing it. The pink skinlike layer should be removed from the surface. Place the meat in the roasting pan on a rack or use a roaster which is supported upon a rim which holds it up from contact with the bottom of the oven. Brown the surface well in a hot oven. This will probably require about 15 minutes. Then reduce the heat and continue the roasting, allowing 15 minutes to each pound of meat or a little longer if the cut is thick. In case gas is the fuel used and the roast is a small one the preliminary browning can be done more economically in a frying pan over one of the top burners. Baste the roast every 15 minutes unless a covered roaster is used.

If the meat rests upon a rack a small quantity of water may be kept in the bottom of the pan to prevent the drippings from becoming too brown. The water should not come in contact with the roast.

Some of the sauces and relishes suitable for serving with roast lamb or mutton are suggested here.

MINT SAUCE.

¼ cup finely chopped mint leaves.
½ cup vinegar.
1 tablespoon sugar.

Mix all the ingredients and let stand for an hour before serving.

MINT JELLY.

Apple jelly flavored with mint is a very good accompaniment for roast lamb or mutton. Make apple jelly as usual, and when ready to pour flavor it with mint or mint extract. Mint jelly may also be made by flavoring gelatin with mint.

CURRANT-JELLY SAUCE.

Pour off the excess fat from the drippings in the pan. Brown 2 tablespoons of flour in 2 tablespoons of the fat and add to the drippings. If necessary more hot water should be added. Boil the sauce until it thickens, stirring well from the bottom and sides of the roaster. Season with salt. Strain the gravy if necessary. Beat in one-half glass or more of currant jelly. Serve hot.

APPLE GARNISH.

One-half hour before the roast is done pare and core sour apples, cut them in quarters and place in the roaster where they will bake in the drippings. When the apples are done serve with the drippings in a heated gravy dish.

SPANISH SAUCE.

2 tablespoons lean, raw ham, chopped.
2 tablespoons celery, chopped.
2 tablespoons carrot, chopped.
1 tablespoon onion, chopped.
¼ cup butter or other fat.
¼ cup flour.
1½ cups water or stock.
½ cup strained tomato.
Salt and pepper.

Cook the ham and vegetables slowly in the fat until done. Add the flour, stock, and tomatoes. Season with salt and pepper. Cook for five minutes and serve.

BROILED CHOPS.

Trim the pink skin and superfluous fat from the chops and broil them quickly on both sides by turning them back and forth on the broiler or in a hot, dry, frying pan. As soon as they are well seared and brown reduce the heat and finish the cooking, which should take from 8 to 12 minutes in all according to the thickness of the chops and whether they are liked rare or well done. In case the broiling is done in a pan pour off the fat as it cooks out in order to prevent the chops from frying in their own fat. Since broiled chops should be served promptly the other dishes of the meal should be practically finished before the broiling is begun.

ONION SAUCE FOR CHOPS.

6 large white onions, ground fine.
1 teaspoon sugar.
Salt.
¼ cup of butter or other fat.
1 tablespoon flour.

Cook the onions, sugar, salt, and half the butter together slowly for about 45 minutes. Melt the remaining butter, blend the flour with it, and add to the cooked onion, stirring well until the mixture boils. Serve hot with chops or roast.

PURÉE OF NAVY BEANS TO ACCOMPANY CHOPS AND ROAST.

1 pint beans.
1 onion.
1 carrot.
1 sprig parsley.
Pepper.
¼ pound salt pork or 2 tablespoons mutton drippings.
2 cloves.
½ teaspoon salt.
1 quart water.
1 tablespoon butter.

Soak the beans overnight, drain, and add the other ingredients with the exception of the butter. Boil for 30 minutes and cook in a moderate oven for one hour. Remove the onion, carrot, and parsley, and press through a sieve. Add butter and salt, if necessary, and reheat. Similar purées may be made from red kidney beans, split peas, and lentils.

LAMB OR MUTTON LOAF.

Grind any lean lamb or mutton, using the fine blade of the grinder, season with salt and pepper and form into a loaf. Oil the surface with melted fat, dredge with flour, and brown well in a hot oven. Reduce the heat and cook slowly for one hour. Serve with tomato sauce (see p. 9).

LAMB OR MUTTON SAUSAGE.

1 pound lamb or mutton free from bone.
½ pound fat fresh pork.
⅛ teaspoon black pepper.
½ teaspoon salt.
¼ teaspoon each marjoram, thyme, and sage.

Put the meat through a grinder and mix thoroughly with the other ingredients. Form into cakes and fry till well done.

"BOILED" LAMB OR MUTTON.

The first thing to be remembered is that "boiled" meat is not boiled but simmered.

Prepare the leg or shoulder for cooking. Have ready a large kettle containing enough boiling water to cover the meat. Lower the meat into the water, taking care that it is entirely submerged. Bring the water again to the boiling point, then place kettle where water will simmer as shown by continued motion on one side of the kettle. Continue the simmering until the meat is tender, from an hour and a half to two hours for lamb and from two to three hours for mutton. While cooking add to the water salt, pepper, and any other seasonings liked. Avoid piercing the meat with a fork. Serve either hot or cold.

SAUCES FOR "BOILED" LAMB OR MUTTON.

CAPER SAUCE.

Make a thin sauce using 1½ tablespoons butter or other fat, 1½ tablespoons flour, 1 cup water or clear soup stock, ½ teaspoon salt, and pepper according to taste. Add ½ cup of capers drained from the liquor in which they were bottled.

MOCK CAPER SAUCE.

Make a sauce according to the directions for caper sauce but use chopped pickle or chopped stuffed olives instead of capers.

TOMATO SAUCE.

1 cup strained tomato.
½ cup water or meat stock.
1 bay leaf.
1 teaspoon salt.
Pepper.
4 tablespoons butter or drippings.
4 tablespoons flour.

Brown the flour lightly in the fat. Add the tomato juice, water, and seasonings. Stir the mixture well until it boils up thoroughly. Remove the bay leaf before serving.

PARSLEY SAUCE.

2 tablespoons butter or rendered lamb or mutton fat.
2 tablespoons flour.
1 cup milk or mutton broth.
Salt.
Juice of ½ lemon.
1 tablespoon finely chopped parsley.

Melt the fat, add the flour, and cook for two or three minutes, stirring constantly. Add the milk or broth and cook until the liquid is thickened. Season with salt. Just before serving add the lemon juice and parsley.

HORSE-RADISH SAUCE NO. 1.

(For cold boiled mutton.)

2 tablespoons cracker crumbs.
2 tablespoons butter or mutton fat.
½ teaspoon salt.
1 cup milk.
¼ cup grated horse-radish root.

Cook the crumbs, horse-radish, and milk 20 minutes in a double boiler. Add the remaining ingredients and serve either hot or cold.

HORSE-RADISH SAUCE NO. 2.

⅓ cup thick cream.
3 tablespoons grated horse-radish root.
1 tablespoon vinegar.
Salt and cayenne.

Whip the cream and add the other ingredients.

BAKED STUFFED SHOULDER.

Remove shoulder blade and fill the cavity thus formed with a stuffing made of the following ingredients:

1 cup cracker crumbs.
4 tablespoons butter or other fat.
¼ cup boiling water.
½ teaspoon salt.
¼ teaspoon pepper.
A little sage or thyme if liked.

Mix the seasonings with the dry crumbs and moisten with the butter and hot water.

Place the prepared meat in the roasting pan. Rub drippings over the surface, sprinkle with pepper and salt, dredge with flour, and brown quickly in a hot oven. Pour half a cup of hot water over the meat, adjust the cover of the roaster closely, and cook two to three hours in a slow oven. No basting will be required.

Serve with a sauce made by heating a half cup of chopped sweet pickle of any sort with the gravy in the pan.

BROWN STEW OF LAMB OR MUTTON.

Cut lean lamb or mutton into small pieces, season these with salt and pepper, dredge them in flour, and brown on all sides in hot fat. Remove to a saucepan and half cover the meat with hot water. Let simmer until tender. Thicken the broth with a little flour which has been browned slightly in an equal amount of fat. Serve with plain boiled or baked potatoes and a green salad.

If a combination with vegetables is liked, these should be cut into small pieces and added in ample time for them to be thoroughly cooked without the necessity of actually boiling the stew. Starchy materials such as rice or macaroni should be cooked separately, although potatoes cut small can be cooked satisfactorily with the meat at the simmering temperature.

The variations which can be made upon the plain stew are suggested by the following list of vegetables and seasonings, which may be added singly or in combination: Apples, string beans, lima beans, cabbage, carrots, celery, eggplant, okra, onions, peas, peppers, potatoes, radishes, squash, tomatoes, and turnips; curry powder, celery seed, garlic, thyme, marjoram, parsley, bay leaves, lemon juice, and capers.

BREAST OF LAMB WITH VEGETABLES.

Season a breast of lamb with salt and pepper and simmer until the bones can be slipped out easily. Remove from the water. In the meat stock cook vegetables such as turnips, carrots, celery, or onions cut in small pieces, green beans, peas, and okra. More salt may be needed. A few potatoes cut small may be added to cook during the last 20 minutes.

Remove the bones from the meat, fold it together, and secure with small skewers or twine. Dredge with flour and brown on both sides in hot fat. Place on a hot platter and surround it with the vegetables which have been well drained.

BRAISED BREAST OF LAMB OR MUTTON.

Season a breast or shoulder of lamb or mutton, place in a covered casserole or roaster and surround by vegetables prepared as in the previous recipe. Add a little water, cover the pan closely, and cook in a slow oven until the meat is tender, probably from an hour and a half to three hours.

PRESSED LAMB.

Simmer the head, neck, and other ragged pieces of lamb in a small amount of salted water until the meat falls from the bones. The lamb liver may be included. When cool remove the bones and excess fat, add a little lemon juice and other seasoning to taste, and chop or grind the meat. Dissolve a tablespoon of plain gelatin in one cup of the liquor from the saucepan and pour over the meat. Mix well, place in a suitable mold, and put in a cold place. When the jelly has set, it may be cut in slices and served.

THICK SOUP.

Thick soup which may be served as the main dish at luncheon or supper may be prepared from the neck, rib ends, shanks, and other bony parts of the carcass.

Place meat and bones together in a kettle, using water sufficient to cover. Season with salt and two or three cloves and peppercorns. Let simmer until the meat can be easily separated from the bones, then pour through a colander. Set the strained broth aside to cool in order that the fat may be removed easily. Carefully free the meat from the bones and chop it fine. After removing the excess fat from the broth return the latter to the kettle and add any desired combination of chopped carrots, onion, celery, turnips, and potatoes which have been previously cooked together either in a little water or in a steamer above the soup kettle; also previously cooked rice, barley, macaroni, or spaghetti may be added if desired. Reheat the soup, add the chopped meat, and serve hot. If dumplings are liked, these may be cooked in the soup just before the meat is added. Since the dumplings must be boiled and the meat should not be boiled, do not return the meat to the kettle until the dumplings are done.

DUMPLINGS.

Dough prepared as for baking-powder biscuit may be rolled out about half an inch thick, cut with a small cutter, and cooked for 10 minutes on the top of the boiling soup. The kettle should be kept covered during the entire time of cooking the dumplings.

UTILIZATION OF LEFT-OVER COOKED MEAT.

Housekeepers are sometimes at a loss to know how to utilize the less desirable parts of a cut, since often there is not enough of this to make the preparation of an extra dish from the fresh trimmings worth while. The first suggestion would be that whenever the results would be at all satisfactory, the piece of meat be prepared untrimmed. For example, the flank which comes with a loin roast may be folded under and cooked with the loin itself. So cooked it would be ready not only for possible use later but would stand a chance of being used and enjoyed at the first serving. Again, the less desirable portions may be ground fine, seasoned well, and cooked under the main cut, as a dressing. In short, the hint is given that the utilization of tough meat does not always mean soup or a stew.

Once the meat is cooked there are numerous and simple ways for making use of the left-overs. A few suggestions are given below:

COLD SLICED MEAT.

If the left-over meat can be sliced and served cold the process is quite simple. With this cold meat serve a hot dish such as creamed potatoes or scalloped tomatoes.

SALMI OF LAMB.

Cold cooked lamb which is not in shape to serve sliced may be cut into smaller pieces and reheated in Spanish sauce (see p. 7).

CROQUETTES AND MEAT CAKES.

All sorts of scraps of the cold cooked meat may be ground fine, seasoned well, bound together with gravy or mashed potato, formed into croquettes, dipped in egg and bread crumbs and fried in deep fat. The meat may be formed into flat cakes, dredged in flour and browned in a little fat in a frying pan. Avoid having the mixture too dry, and never use raw flour as a binder, since it is not sufficiently cooked in the short time required to fry the cakes.

MUTTON OR LAMB PIE.

Chop scraps of cold meat into small pieces, cover with gravy, or hot water and savory fat, season as desired and heat in a baking dish in the oven. When thoroughly heated cover the top with a crust made as for baking-powder biscuit. Return to the oven and bake until the crust is done.

MOLD OF LAMB OR MUTTON AND RICE.

A more delicate "pie" is made by lining a buttered baking dish with cooked rice, filling with the chopped meat and gravy, covering this over with more rice. Set the dish in a steamer and steam for one hour. The "pie" may be served from the dish, or with care it may be turned out whole on a platter, where it will appear as a mound of plain rice.

QUICK LAMB PATTIES.

Quick patties may be made by baking shells of pie crust or biscuit dough in muffin pans and filling these with hot meat and gravy such as is used in the preceding recipe. Meat may be similarly served on slices of toast.

LAMB OR MUTTON SALAD.

When the amount of left-over meat is small it may be combined with vegetables or hard-cooked eggs and served as a salad.

SPECIAL RECIPES FOR MUTTON.

A few recipes specially adapted to the preparation of mutton rather than of lamb are given below:

CURRY OF MUTTON.

2 pounds mutton from the forequarter.
1 onion.
1 teaspoon vinegar.
1 teaspoon curry powder.
Salt.
Boiling water.
2 tablespoons flour.

Fry the meat in a little of the fat until it is a delicate brown. Add the onions and pour over all enough boiling water barely to cover. Cook until the meat is tender. Add the curry powder, vinegar, and salt. Remove the meat, reduce the broth to 1 cup, and thicken it with 2 tablespoons of flour blended with 1 tablespoon of melted fat. Add the meat to the gravy and reheat. Serve with rice.

SHEEP'S TONGUES.

6 sheep's tongues.
2 carrots cut into small pieces.
1 pint boiling water.
1 large onion cut into small pieces.
2 slices bacon.
¼ cup capers.
3 small cucumber pickles.
Salt and pepper.

Scald the tongues, throw them into cold water, and remove the skins. Cover the bottom of a baking dish with bacon cut into fine strips, place over this the tongues, season with salt and pepper, and cover with another layer of sliced bacon. Add the minced carrots and onion, salt and pepper to taste, and about a pint of boiling water or broth. Cover the dish and cook slowly for about three hours. Take out the tongues and place them on a hot dish, strain the sauce, reheat, add one-fourth cup of capers and three small cucumber pickles, sliced thin. Stir well and let the sauce boil up once. Pour over the tongues and serve.

TURKISH STUFFED TOMATOES.

In Turkey a number of dishes are prepared from mutton which are interesting from the point of view of the food customs of another country, and also palatable. The following recipe for stuffed tomatoes is a little different from many used in this country:

2 tablespoons cooked rice.
½ pound raw mutton.
2 onions.
12 smooth round tomatoes.

Pass the materials through a meat grinder; season with salt, pepper, and chopped parsley; fry in a pan for 10 minutes, stirring constantly. Wash the tomatoes, cut a thin slice from the stem end, leaving a little of the skin for a hinge, remove the seeds and pulp, and fill with the meat mixtures. Bake in a pan for 20 minutes, lift out with a broad knife and serve hot.

MUTTON AND EGGPLANT PIE.

Eggplant pie is a simple dish made by cooking together in a baking pan alternate layers of eggplant and of chopped mutton fried in its own fat. A little tomato juice may be added or a few sliced tomatoes. Bake until well browned.

MUTTON BAKED WITH APPLES AND ONIONS.

2 pounds mutton cutlets from neck.
Salt.
1 onion.
4 medium-sized sour apples.

Prepare the meat by removing the bone and superfluous fat. Season with salt and lay in a baking dish. Cover the meat with finely sliced apples and finely chopped onions. Bake in a moderate oven until the meat is tender, which will be about 1 hour.

SOUPS AND BROTHS FOR THE SICK.

Probably because of its characteristic flavor lamb or mutton are seldom used in the making of a clear soup or consommé for serving as the first course for a dinner. The following directions for the preparation of clear soup, broths, and meat juices are therefore given especially from the point of view of food for the sick:

LAMB OR MUTTON JUICE.

To a half cup of lean lamb or mutton finely ground, add an equal amount of cold boiled water. Stir the mixture well until the meat becomes grayish in color. Strain through cheesecloth or a very fine wire strainer, being careful to press out all the juice. Pour the juice into the cup in which it is to be served. Stand the cup in a small saucepan and carefully pour boiling water around it to the height of the liquid in the cup. Stir the juice constantly until it becomes hot enough to be palatable, usually from 3 to 4 minutes. Season with a little salt and serve at once.

This "tea" contains most of the flavoring matter of the meat and a part of the albumin and of the mineral salts, but while it is appetizing in flavor its food value is not great.

A clear soup of good flavor which contains gelatin as well as mineral matter, and is for this reason more satisfactory for use in cases wherever liquid food alone must be depended upon for some time, is prepared as follows:

2 pounds of neck of lamb or mutton. | 1 cup of cold water.

Remove the excess fat from the meat and chop both meat and bones into small pieces. Add the water, place in a double boiler and cook for 4 or 5 hours. Strain through muslin. Season with salt (if salt is allowed). Let stand until the fat hardens. Remove the fat and serve the soup either hot or cold as preferred by the patient. If lamb fat has been prescribed a teaspoonful should be added to each half cup of soup, which will, of course, need to be served hot. Even though this extract gelatinizes on cooling, it can still be served in a liquid diet for the reason that the solid gelatin becomes liquid as soon as taken into the mouth.

SUMMARY.

Lamb and mutton have long been important foods in many parts of the world.

Mutton is very popular in England, but in America lamb has been preferred to mutton and is consequently much higher in price.

Many persons dislike mutton and even lamb on account of the texture of the fat, but the fat may be rendered more accĕptable if carefully prepared and served hot.

Few full-grown sheep weigh over 75 pounds when dressed, and dressed lambs range lighter. The ease with which animals of such weight can be slaughtered on the farm makes the sheep a very desirable animal for use in supplementing the farm supply of fresh meat.

When a lamb or sheep is slaughtered on the farm it is best to divide the carcass into simple divisions, thus avoiding numerous cut surfaces.

To avoid spoilage, methods of preservation should be used without delay.

Only about 45 per cent of the live weight of the lamb or sheep appears as dressed meat. Of this about 19 per cent is bone. It is not possible to state exactly what the amount of waste will be in any given retail cut because of variations in the size and grade of the carcass.

The carcasses of all meat animals contain tender flesh and that which is less tender. The muscles which have been little used are tender, while those which have been actively exercised are comparatively tough.

The cooking of tender meat is a simple process. Usually the piece is seared quickly on all sides by using intense heat, after which the heat is reduced and the meat is cooked to the desired degree in its own juices.

In tough meats the connective tissue is the part to which the housekeeper must direct her attention. The meat may be finely ground, which will divide the connective tissue into small pieces, or the meat may be simmered in water for some time, by which means the connective tissue will be gelatinized and softened, yet the meat itself will not be "boiled" to pieces.

Variety may be obtained by the use of suitable sauces and other accompaniments.

The utilization of trimmings and left-overs does not always mean a soup or a stew. With a little forethought the practicing of economy here need not be too apparent.

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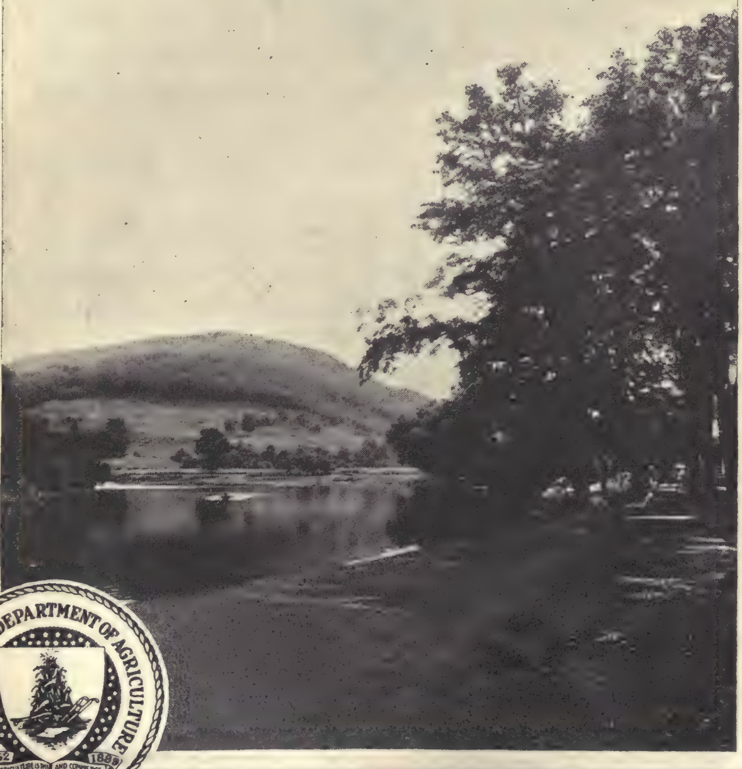
FARMERS' BULLETIN No. 1325

RURAL PLANNING
The SOCIAL ASPECTS



THIS BULLETIN is practically an exhibit of actual examples of rural planning by rural people.

It shows their endeavor not only to create and improve their own institutions, such as recreation places, public grounds and public places, and trade and civic centers, but to conserve for the permanent use of rural people those institutions and auxiliaries of rural life, of proved value, that they already have.

It shows especially that country people do believe in beauty in country places; that they appreciate it; and that they can and do afford civic beauty in their own environment.

Its purpose is not to tell how things should be done but to show what has actually been done.

It is hoped that the story of how these instances came about will encourage country people everywhere to plan for beautiful surroundings while planning for better farming.

Washington, D. C. Issued May, 1923

RURAL PLANNING—THE SOCIAL ASPECTS

Wayne C. Nason, *Junior Economist, Bureau of Agricultural Economics.*

WHY RURAL PLANNING.

RURAL PLANNING is about to have its day in court. We have heard much in recent years, and rightly so, of city planning, the proper arrangement, development, and use of city land, utilities, and institutions, in order to bring about the greatest well being and enjoyment of the citizens. Much has been accomplished toward making cities more orderly, comfortable, and more satisfactory places in which to live.

But half the people and almost all the territory of the United States are outside of organized cities. As the country has developed, the necessity of doing in a general way for the country what city planning has done for the city has become increasingly apparent. Proper construction and orderly arrangement of roads, villages, public grounds and buildings, farms, farm homes, rural parks, and gateways to town and country, bearing in mind good taste as well as utility, can accomplish much. Rural planning involves not only the construction of the new, but the preservation through private benefaction or local government of the old, especially that of community interest, such as picnic and playgrounds, and spots of natural beauty or historic interest—lake shores, river banks, hills commanding good views, waterfalls, scenic drives, glens, local monuments, and memorial places. These are the common property of the people, and should be preserved for the use of the people for all time.

The problem of rural planning may be approached from various angles, such as the economic, the technical, or the social. It would not be difficult, perhaps, to prove that planned rural development would be an economic asset to the farmer, the community, and the State, but that is not the purpose of this bulletin.

The technical work of rural planning, such as the actual structural work in building roads, bridges, parks, farm homes, and public grounds, or the drawing up or putting into execution of landscaping or planting plans, as such, important though it all is, can not receive consideration here. We are interested rather in the social viewpoint, that which affects the human side of farm population groups and community life, especially as applied to country living conditions. Such a study should show the incentive, the motive, the difficulties encountered, and the successes achieved, by groups of rural people in their attempts to discover the beautiful in nature and to reveal it, and to influence the production of beautiful things in public places, and should prove helpful in estimating the value of a policy of rural planning in the development of American country life.

SPECIFIC EXAMPLES OF RURAL PLANNING.

RECREATION PLACES.

Much has been written in recent years concerning the need of increasing the recreation, play, and athletic facilities of city people. It has been argued that country people get enough physical exercise from the manual labor they perform, but this leaves out of consideration the fact that much farm labor is such a severe and continuous strain that it develops certain physical defects which make necessary corrective exercises and forms of relaxation in the nature of games and play. It is well known that too much or too long-continued physical labor is sometimes deadening to the soul and benumbing to the spirit. On the other hand, one of the chief values of games is that they develop initiative, agility, self control, leadership, teamwork, and the capacity for cooperation.

Formerly the rural population found recreation in picnicking, swimming, boating, fishing, or hunting. People were free to go to a neighboring hill, forest, lake, or stream for their outings. These were then part of the public domain open to everyone, but they are now rapidly passing into the hands of private owners who exclude the public from their use. Unless a determined effort is soon made, preferably by State and local governments, strongly supported by local organizations, to preserve these natural heritages for the use of the people, one of the most pleasant and effective sources of rural recreation and enjoyment will have passed forever.

LOCAL RESERVE HOLLAND GLEN, BELCHERTOWN, MASS.

In western Massachusetts, near the northern end of the Holyoke Range, a spring gives rise to a small stream which, fed by other springs on its way, flows through Belchertown and eventually finds an outlet in the Connecticut River. Shortly after its rise it spreads over a wide ledge of rocks and begins a picturesque course with a drop of about 14 feet. (Fig. 1.) This is the beginning of Holland Glen, named after J. G. Holland, the talented author and editor, during the latter part of the last century, who was born near the glen, and whose family is said to have owned it. For a distance of half a mile the stream has cut a gorge from 40 to 100 feet deep and from 75 to 250 feet wide at the top. At the other end of the glen are the lower falls, 200 feet below the first. Between the two falls, within an area of about 8 acres, is a scene of great beauty and one of exceptional interest to lovers of nature. The glen is carpeted with a profuse growth of moss and ferns and such flowers as laurel, anemone, trailing arbutus, hepatica, trillium, and dog-tooth violets. There is a fine stand of old-growth timber, consisting of hemlock, pines, birch, oak, ash, and beech. This is said to be the only remaining primeval forest in that section and one which, if destroyed, would take centuries to replace.

For more than a century the citizens of Belchertown and vicinity had enjoyed the delights of the glen. During all these years the people of the village had thought of it almost as their own. Only a few miles from the town center and with a good road leading to it, they had looked upon it as their outdoor playground. Family parties, farmers' clubs, granges, Sunday schools, churches, schools, and societies made it a common picnic ground.

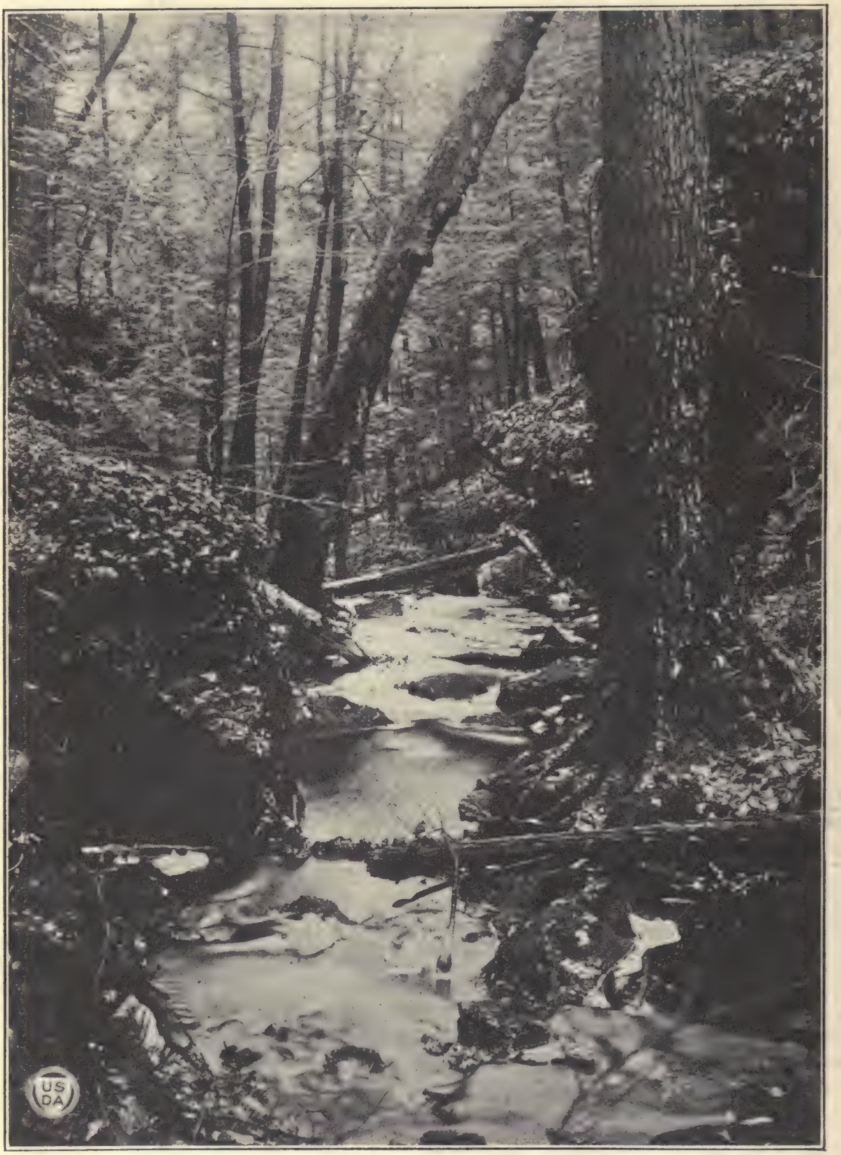


FIG. 1.—Holland Glen, Belchertown, Mass.

The glen was more than a local institution. Its fame had extended for miles. It was well known in Amherst, Northampton, Holyoke, and Springfield. Its attractions appealed to the citizens and college students of these places and they came to the glen by groups and by societies. Visitors even came from New York and Boston.

Not social desires alone were gratified at the glen. It had a many-sided appeal. Botany classes found their richest material there. To students of geology it revealed the story of the earth's growth. The zoologist found a fertile field for his study, and the artist encountered a challenge in attempting to picture the charms of the scenery.

"Who owns the glen?" What difference did it make? Judging by its use it belonged to the people. As far back as memory and even tradition went it had been freely used by everyone. Why think of the future? But as often happens in such matters, complacency received a sharp awakening. News came that a lumber company was about to acquire title to the land at the upper end and cut the timber. The result, it was feared, would be the drying up of the stream and falls and the practical destruction of the place as a public picnic ground and haunt for nature lovers.

Belchertown had a local historical society with about 30 members. Some prominent members sensed the danger of the situation and began agitation, especially through newspapers, for ownership of the glen by the society. One member immediately took an option on the timber, a committee was appointed and a campaign for funds started. Just when they thought they had sufficient funds another lumber concern bought the tract at the other end of the glen. More money was forthcoming to buy the rights of this company and the historical association assumed notes to secure the title to the entire tract. Ultimately, the amount sufficient to obtain title was secured, about $1,000, subscribed by more than 100 people, and the glen became the property of the society.

The struggle had taken several years and was not without its lights and shades. When it was heard that certain lands were wanted by the association, they were immediately purchased by speculators, who sold to the association at a profit. On the other hand, 10 acres adjacent to the glen were contributed by a progressive farmer.

The strife for possession being over, the association is now planning for the development of the tract. It is proposed to make the place more easily accessible, especially for teams and automobiles, by a new entrance directly at the end of the glen. Footpaths and bridges are to be built the full length in order that all the attractions of the place may be enjoyed by visitors.

The construction of the Belchertown-Amherst State highway will make the glen more readily accessible. Ownership by a public society promises a sane development along lines limited only by the common welfare.

RURAL COMMUNITY PARK, MARION CENTER, PA.

Who is insensible to the appeal of the old swimming hole when memory brings it back? Especially strong is the link with the past when the old swimming place is interwoven in memory with the old picnic ground. At no place, perhaps, has the strength of these ties been more manifest, if measured by results, than in the rural community of Marion Center, Pa. Since the day when the land was deeded by a grateful Government to a Revolutionary War veteran, the little strip of woods on the edge of the village had been the center of the outdoor social life of the community. Every man and woman living in Marion Center since had come under its influence. The children had waded in the stream and bathed in the pool. The young men had played many a baseball contest near by. The girls had gathered wild flowers on the banks of the stream in summer and skated on its ice in winter. Home groups, farmers' clubs, schools, churches, lodges, and societies, not only from Marion Center but from miles around had picnicked in the grove. Since the days of the Revolution Independence Day had been celebrated there. Once a year since the Civil War the whole countryside had gathered there in memory of the dead. When the great World War was over, it was there that the people gathered to welcome home their heroes. Many a warm political campaign had been inaugurated under the elms and oaks. The religious life of the community had been quickened at campmeeting time. And once a year those who had gone away from the home community came back to be welcomed by relatives and friends at the home-coming celebration.

The spot (Fig. 2) had always been considered an integral part of the community, a permanent institution just as much as the town government, the church, the school, or the grange. It had always been there for the free use and enjoyment of the people and always would be. When it was suddenly learned that this hallowed spot was in danger of being sold, that an outside corporation was about to denude the place of its timber and that as a result of this the spring and stream could dry up the people were in dismay. The spirit which animated the old Revolutionary War veteran took hold of the people. The matter was discussed by men and women in groups and small gatherings. Finally a mass meeting was held and after much discussion it was determined to organize a community association and purchase the piece of land "to preserve it forever for the free use of the people."

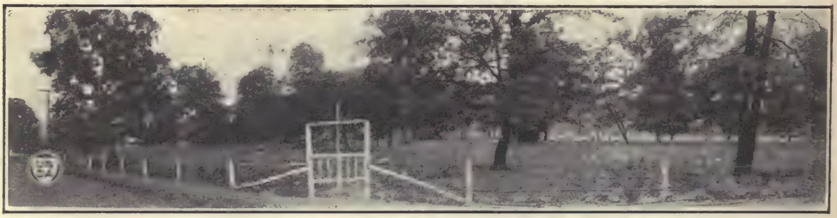


FIG. 2.—Rural community park and playground. Old swimming hole in background. Marion Center, Pa.

General contributions were decided upon as a method of financing the project, but there was no soliciting except through advertising in the local newspaper. There were 400 contributors from the village of 500 population and its surrounding farming section, half of the contributors being farmers. A notable response came from former residents of the village. The sum of $2,800 was realized and the 14 acres of land purchased.

Much work yet remained to be done before the ideal in the minds of the people could be visualized. Tiling was put in and ditches dug for drainage, roads and paths were built and surfaced with cinders, bridges were constructed, brush was grubbed out, rustic seats and picnic benches and tables were placed, the spring was curbed, a grand stand was improvised, electric lights were installed, and the baseball diamond was improved. An auditorium, 40 by 70 feet, is now under construction.

Voluntary labor and free materials were donated. A man who owned timber rights on the ground gave his profits on it to the association. The railroad hauled many carloads of cinders without charge and a dozen teams and the labor of many extra men was given during successive summers. To prevent the erection of anything unsightly between the borough line and the park, arrangements are under way to purchase seven intervening lots.

Seven trustees, four of whom were farmers, were elected by the subscribers to control the park, ownership resting with the association. A clause in the deed stipulates that should the property cease to be used as a public park the title would revert to the original owners.

The park is open to all organizations for any public use upon payment of a small maintenance fee. All concession privileges are retained by the association and receipts are placed in the maintenance fund. During a recent grange picnic, attended by 3,000 people, more than $200 was realized from concessions.

A notable feature of the establishment of this park by the community was the ease and smoothness with which the operations were carried on. There were few difficulties to overcome and fewer objections made. Nearly everyone was in favor of the project and a fine spirit of cooperation was manifested. It served not only to solidify the various elements of the village and the adjacent farming section, but also to cement the ties binding to the home community those who had moved away.

The fame of this beauty spot and playground, the open-air center of a small rural community, has spread to various neighboring sections, and a number of villages are watching the outcome of the project with the idea of adopting similar plans.

RURAL ATHLETIC FIELD AND COMMUNITY CENTER, WORTHINGTON (BERLIN), CONN.

A dream of many years standing is now being realized in the rural community of Worthington, Conn. For a long time the leading men and women had been considering the desirability of a place that would serve for the recreational and social development of the neighborhood, the use of which would not be limited by the control of any one particular club or society but would tend to bring together the different elements of society in order that a harmonious and progressive community might be built up. Particularly there was need of a place where the local Boy Scouts and other young people's organizations could meet and carry on outdoor exercises. The pastor of the local church was perhaps the originator of the idea. Some years before the church had rented a hall to be used as a recreation center, but now something more comprehensive seemed to be needed.

While the project was under consideration a fortunate circumstance, from a community viewpoint, occurred. A house with ample grounds, near the center of the neighborhood was destroyed by fire. A favorable opportunity was thus afforded for establishing the much-desired recreational center by securing control of this property.

The question was publicly agitated and mass meetings were held in the town hall for the discussion of the matter. The owner of the property agreed to donate it to the community if a responsible organization could be formed to receive title thereto. For this purpose the Worthington Community Association was incorporated with 12 charter members. A voting membership was organized of local men and women who should pay the annual membership fee of $1. People outside the neighborhood were organized as dues-paying but nonvoting members. The voting members elect a community council for purposes of management and the members of this council elect the usual officers from their own number. The grounds are open to the free use of all local residents whether members or not. (Fig. 3.)

Two thousand one hundred dollars was raised by subscription from 60 people for the purpose of putting the grounds in the desired condition. Much labor and materials were contributed. The center is maintained by membership dues, receipts from entertainments, and other sources. The last sheep roast realized $350 and a lawn féte and sale netted $200.

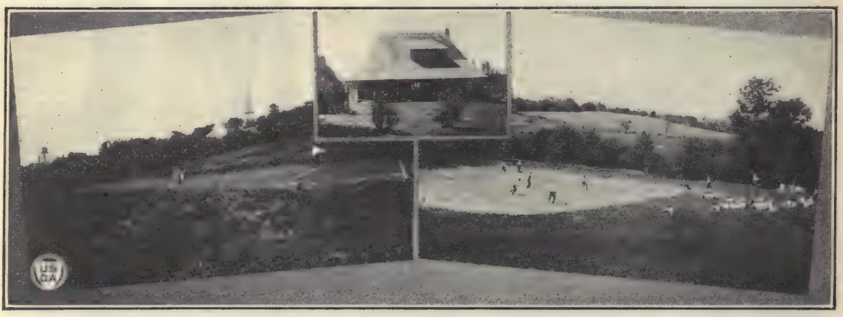


FIG. 3.—A rural community athletic field and community center. Worthington, Conn.

The grounds comprise 9 acres and the boundary lines are defined by a row of elms and cherries, while various kinds of shade trees are scattered over the upper part of the field. In the immediate front are vines and flowers. A baseball diamond has been made at the rear of the field and tennis courts have been constructed near the center. The barn has been reconstructed into a club house and furnished with folding chairs, tables, and benches. A fireplace gives a cheering and homelike touch and was built of stone, each member bringing one stone; some stones were brought from other States. The club house is used by the boy scouts, parent teachers' association, women's aid society, girl scouts, Daughters of the American Revolution, motherhood club, and men's club. Fairs, exhibits, dances, food sales, stereopticon lectures, and card parties are held in the building. Baseball games, tennis matches, children's playground exercises, lawn fêtes, and scout drills are given on the grounds.

Plans for the future include a kitchen as an addition to the clubhouse for which the women already have sufficient funds, the installation of croquet grounds, and more playground apparatus.

With the idea of permanence in mind, those in charge of the enterprise have been developing it slowly, and are endeavoring to develop a solid cooperative spirit. This little community of some 200 people has a recreation plant valued at $5,000, with money in the treasury, well-considered future plans, and an institution which, as stated by one of its leaders, "is drawing all people together in a spirit of mutual helpfulness and developing a neighborhood atmosphere which speaks well for the future permanence and welfare of the community."

RIVERBANK IMPROVEMENT AND GATEWAY, UNADILLA, N. Y.

If one travels through the main street of the village of Unadilla, N. Y., on a summer day he will often find some automobile party picnicking on the banks of the stream beside the road. Tourist parties passing through the village, with few exceptions, make at least a short stop there to rest and enjoy the quiet beauty of the spot.

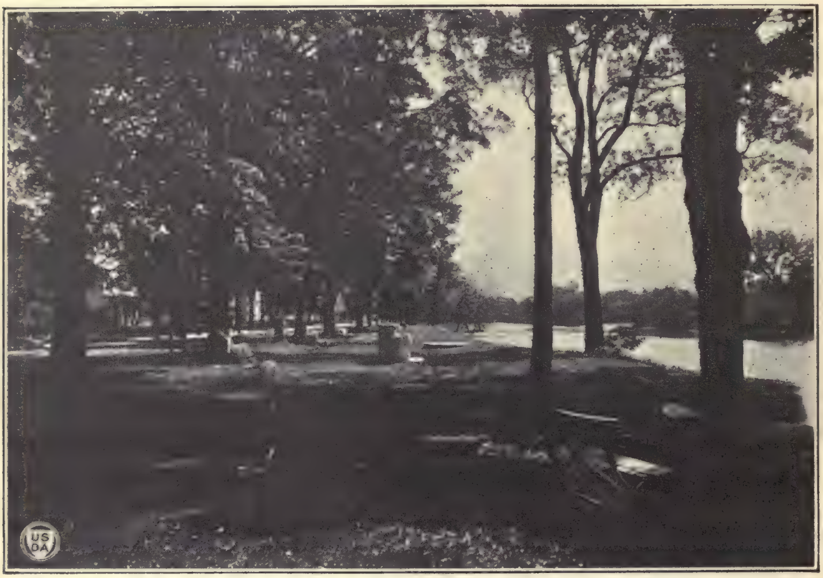


FIG. 4.—A stream becomes a village gateway. Unadilla, N. Y.

The place is a triangular piece of ground 75 feet wide and 400 feet long where the main street and the river meet. The grass has been carefuly cutivated and is kept mowed. A number of shade trees have been planted at desirable places.

The place is known not only to the casual tourist party but to the people of the towns for miles around, who frequently motor to the place to enjoy picnic parties on the banks of the stream. The people of the village, singly and in groups, frequently find diversion or rest here during both day and evening. It is on the Fourth of July, however, that it arouses the full appreciation of the public, for on the evening of that day is held the annual celebration in the nature of a water féte, and thousands gather on the bank to watch the gaily decorated and brightly lighted canoes and the display of fireworks.

The right to use this place was given by two well-to-do families who for generations have retained title to the land in front of their homes and between the main street and the river, as a public expression of the indebtedness which they felt to the community. A further incentive was the wish of the two families to erect a suitable memorial at the entrance of the town in memory of certain of their ancestors.

At a spot commanding the best view of the river and the various vistas a covered memorial seat of granite has been erected and a number of iron seats have been placed about the grounds. There is a small dock with steps leading down to the river. In the center of the plot is a large rock placed there in 1854 by the grandfather of the present owners. A neat fence surrounds all but the river side, with swinging gates as entrances. (Fig. 4.)

No charges are made, as the place is maintained by the owners, who say that they are fully repaid for their care and trouble by the enjoyment of those who use it. A sign placed on the grounds states that the grounds are privately owned but that the public is welcome if proper consideration is shown in the care of the place.

PUBLIC GROUNDS AND PUBLIC PLACES.

The early development of our country has been largely on the material side. Coming to a virgin wilderness, the first duty of our forefathers was to open up a new country and conquer natural difficulties. The struggle for existence was severe, the practical side of life was developed while less attention was given to the esthetic side. It is a hopeful sign that now that we have developed so highly the material side of life, we are beginning to recognize the importance of living itself, that the material must be accompanied by the beautiful and the spiritual if we are to enjoy the fullness of life.

This spirit is being shown in our public grounds and public places; in rural churches where the Creator of the beautiful is being worshipped among beautiful surroundings; in schools where pupils are taught the value of order and beauty by example; in courthouses and city halls which are becoming uplifting influences in the community through their well-planned buildings and attractive settings; in attractive country roads which not merely take one somewhere but which entertain and rest the tired mind on the way; in farm homes where the work side of farm life is separted from and not allowed to smother the home life; and in cemeteries where loved ones are given their last resting place in quiet, beautiful, and dignified surroundings.

RURAL IMPROVEMENT AND A RURAL CEMETERY, DUBLIN, OHIO.

Fortunately not all the beautiful creations of the world are found in the closed estates of men of wealth or the restricted reserves or parks of prosperous municipalities. Some of man's most beautiful handiwork is found in the obscure corners of the earth.

Dublin with its 239 inhabitants was like many other old-fashioned villages located outside the main currents of life. All the essentials were there, the main street, the general store, the blacksmith shop, the country doctor, and of late years a real touch of modernity, the garage; yes, and the old cemetery with its tumbled-down fence and general unkempt appearance. The chief attention it received was the mowing of the grass for the feed it produced. The village did not even own the cemetery. As long ago as 1855 a group of people had formed a cemetery association and bought 6 acres for a burial ground for the use of all the people of the village. In 1915, 4 acres more were purchased. During the years two vaults had been built, one privately and one by the township. (Fig. 5.)

Such were the conditions until about eight years ago the neglect became too much for one of the town's citizens. Appearing unexpectedly before the association he impressed upon the members the neglected condition of the cemetery and stated what he wanted to do.

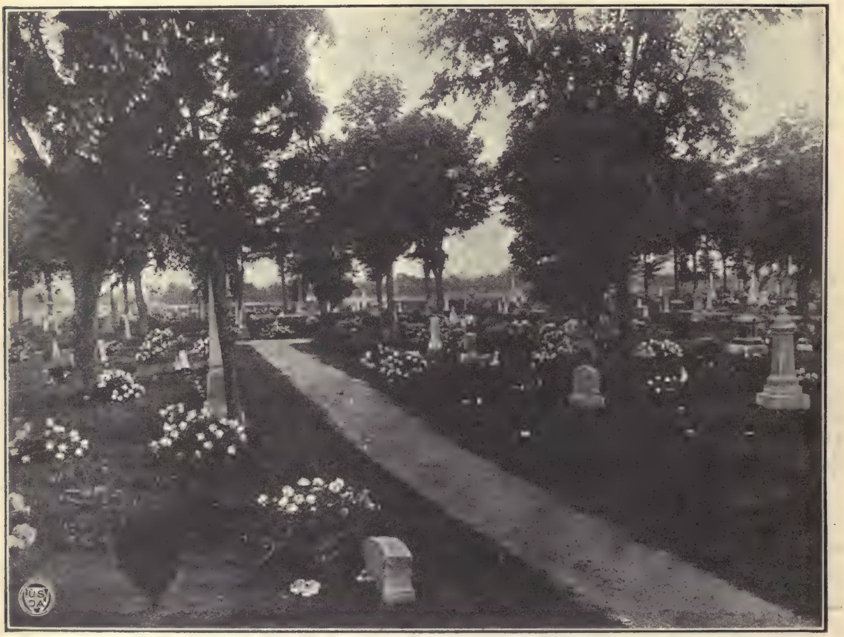


FIG. 5.—An improved rural cemetery. Dublin, Ohio.

The association told him to go ahead with his plans and that they would stand back of him. He was appointed caretaker of the cemetery at moderate pay for actual work done. The fences were repaired, weeds removed, grass cut, and paths built. Again he appeared before the association requesting that money be supplied for the purchase of flowers, trees, and shrubs. Again the association gave him its support in spite of doubt on the part of some members. New trees were set out and the neighborhood ransacked for tulips, hyacinths, rose bushes, and various shrubs. About this time a few peonies were set out on a private cemetery lot by its owners and a vision came to the sexton. Securing permission from the owner, he from time to time divided and transplanted some of them to other parts of the cemetery until it suggested a field of peonies.

There were many discouragements. Many trees were damaged by the cyclone of 1913 and had to be removed. A number of the lot owners failed to keep their lots trim and neat, and the beauty of the cemetery was marred. Rather than have this condition prevail the caretaker assumed the entire care of the cemetery. He was, however, more than recompensed for the difficulties encountered by the faith and support of the association, by the encouragement and cooperation of his townspeople, and especially by the favorable comment upon the beauty of the obscure little cemetery. On Memorial Day people come many miles to attend the simple ceremonies and admire the blooming peonies. And throughout the year many touring parties who have heard of the miracle wrought by the modest caretaker go out of their way to pass by the cemetery and enjoy its restful beauty and dignity.

RURAL IMPROVEMENT AS EXEMPLIFIED BY A PUBLIC LIBRARY, EAGLE ROCK. CALIF.

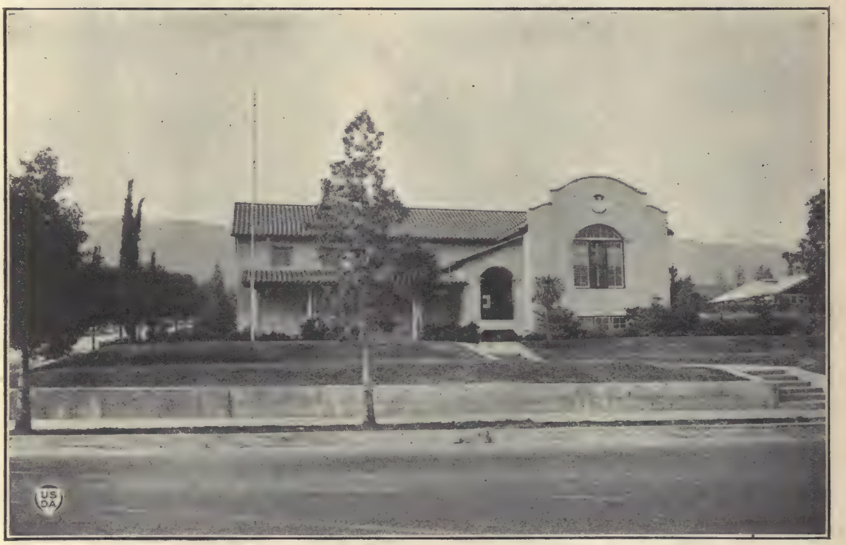


FIG. 6.—A rural library may be housed in beautiful surroundings. Eagle Rock, Calif.

Nearly every public library has a section devoted to illustrated books on art with a considerable treatment of the subject of rural art. Those responsible for the Eagle Rock Library, however, have realized that the making of beautiful things is of as vital importance as assembling information about them. The library building (Fig. 6) is strikingly attractive. Effective use was made of local materials and the principles of the Mission form of architecture were fully employed.

Not content with a beautiful building, those in charge were determined that it should be placed in an attractive setting, even though nearly all available funds were exhausted. In this way they received practical cooperation from local people in the way of plants and shrubs from private homes and neighboring nurseries. Citizens joined with the members of the library board and the librarian in the actual work of planting. As a rule, shrubs and trees adapted to the locality were planted, different varieties of palms, the matilija poppy, and other semitropical plants. The beauty of the open lawn was emphasized while the building was appropriately framed with various ornamental trees planted at either side. Expenses for maintenance are provided by the library tax fund, although plants and shrubs are still often received from local sources.

The library and its grounds furnished an incentive for the improvement of the grounds of other public buildings and private homes, and it is said that the building and grounds have been duplicated in the State of Virginia and even in far-off Persia.

ROADSIDE PLANTING, BURLINGTON COUNTY, N. J.

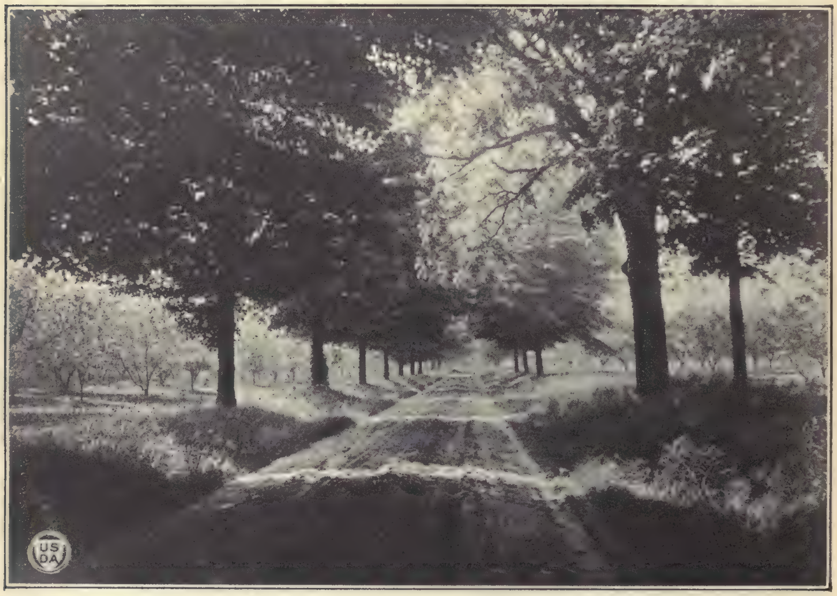


FIG. 7.—A pleasant country road in Burlington County, N. J.

A country road between Burlington and Juliustown, N. J., is shaded by large maple trees. These trees were planted for 1 mile on both sides of the road, between 35 and 40 years ago, by the owner of the adjoining farm for the purpose of improving his estate and furnishing shade to the traveler. Openings at intervals (Fig. 7) provide for views, but the effect would have been increased had the trees been massed a little more.

The heavy foliage of the trees serve to protect from driving winds the fruit trees shown in the illustration on both sides of the road, while the distance of the branches from the ground leaves an open space, so that the air and light may pass through to the crops, and leave the landscape free. Who can set a limit to the measure of time during which these trees will continue to give shade, protection, and pleasure?

SOCIALIZING THE GROUNDS OF A RURAL HIGH SCHOOL, EAST BLOOMFIELD, N. Y.

Several miles from a railway in Ontario County, N. Y., lies the village of East Bloomfield with a population of 275 people. In 1908 the school district voted to erect a new school building. With more than usual foresight it was decided to secure grounds large enough for all the activities connected with a modern school. With this end in view 4 acres of rough farm land located in the center of the district was purchased.

The building (Fig. 8) is an attractive up-to-date school, costing $27,000, with assembly hall, study hall, kitchen, laboratories, kindergarten room, gymnasium, and manual training and home economies (or household arts) rooms, in addition to the usual recitation rooms. In the rear of the building are facilities for basket ball, volley ball, and tennis, with two baseball diamonds and a running track.

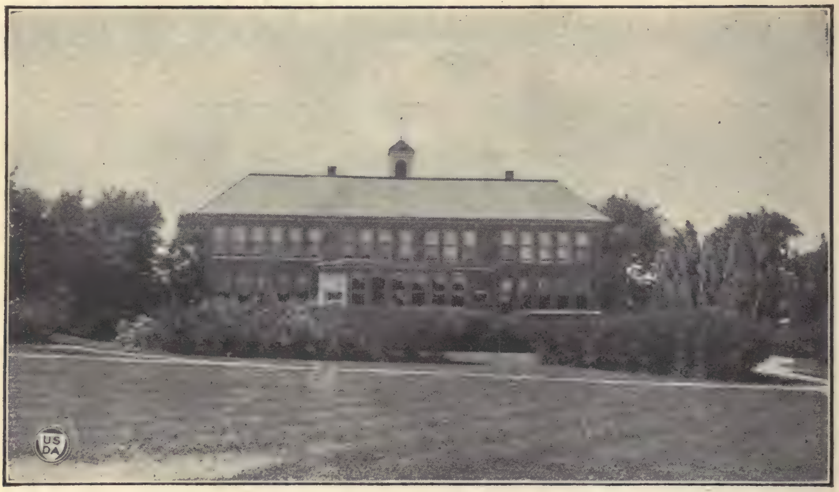


FIG. 8.—An inviting rural high school building. East Bloomfield, N. Y.

In contrast with the usual rural school with its plain building, and bare restricted site, provision was made not only for a building dignified in appearance and of good design with ample grounds, but for a system of ground improvement through plantings and the arrangement of walks, drives, and play spaces. (Fig. 9.) A landscape architect was employed to draw plans for grading and locating cement walks, and for the planting of trees and shrubs. These plans were carried out under the direction of a local civil engineer who also supervised the installation of a thorough system of tile drainage. Planting was begun in 1910 and continued for three seasons. In all about 2,900 trees and shrubs of 90 varieties were planted.

The cost of these ground improvements, met by school funds, was $2,100, itemized as follows: Architect's plans, $100; cement walks, $600; grading, drainage, purchase and planting of shrubbery, $1.400. That the work on the grounds was supervised by the local engineer without cost saved the district considerable expense and furnished a fine example of individual civic interest.

The maintenance of the grounds is provided for by district funds. This expense has been small since the first two or three years, as the shrubbery is set in solid masses so that it soon occupied the ground to the exclusion of all other growth and needs very little attention.

The school board was fortunate in being readily supported by a progressive electorate which realized that the money spent would be much more than offset by the value to the community of the new citizenship developed in such surroundings. Even those with an eye only for the material were favorably influenced by the increase in property values induced by an institution of this kind. Of course there were the usual short-sighted objectors, found in every community, but their objections have largely disappeared.

The results have proved beneficial in some ways not anticipated. Since the school grounds were improved many private grounds in the village have been improved, some in accordance with the plans of the same architect and some under the direction of the same engineer. The grounds of the grange hall have recently been formally arranged and planted.

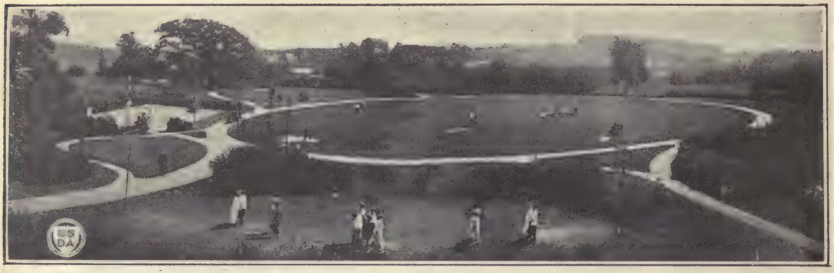


FIG. 9.—A country high school athletic field combining beauty with utility. East Bloomfield, N. Y.

The village is located on the main road from Albany to Buffalo and the school grounds attract the attention of many tourists and descriptive articles have appeared in periodicals published in Kansas City and San Francisco, written by residents of those cities who had observed the grounds in passing. Favorable notice has also been given by the State department of education, the State college of forestry, and the State school of agriculture.

DISTRICT SCHOOL WITH IMPROVED SURROUNDINGS, CANANDAIGUA, N. Y.

On the edge of a beautiful lake shore drive near Canandaigua, N. Y., stood an old one-room wooden schoolhouse erected in 1819. The deed called for land the same size as the building and the outhouses and playgrounds were on highway land. The yard was rough, rocky and weed-covered with a scraggly path leading up to the door. Many in the community recognized that the old school house was a blot upon an otherwise beautiful landscape and when one of the leading citizens became especially interested in the case, there was a rallying cry for improvement. Meetings were held and plans discussed. The man who owned the adjacent farm agreed to give one acre of land for a site. A meeting of taxpayers voted a levy of $2,000 for the erection of a new building and the improvement of the grounds. An endowment fund was decided upon to provide means for maintenance. Through a series of local entertainments, voluntary subscriptions, and bequests, the sum of $1,000 was raised which was accepted by the trustees with the understanding that the interest only would be used, and that for the care and improvement of the ground. This fund was accepted by the University of the State of New York to be held in trust for the purpose intended.

A modern building of good architectual appearance was erected, containing recitation room, library, lobby, cloak rooms and lavatories. Considerable labor was donated by the citizens. The grounds were graded and terraced in accordance with plans drawn up at the State College of Agriculture. Elms, white pine, Norway maple and spruce, dogwood, spiraea, and barberry were planted. A hedge of 100 Lombardy poplars along the rear and one side forms an attractive background. (Fig. 10.)

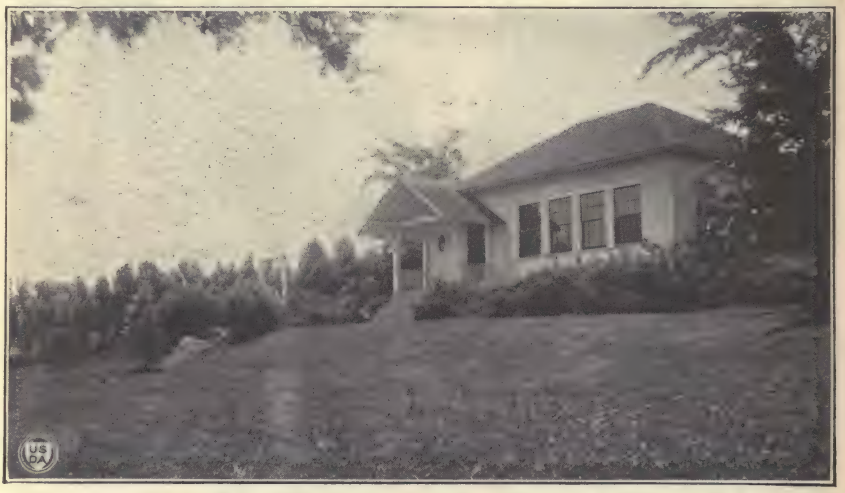


FIG. 10.—A district school may be made attractive. Canandaigua, N. Y.

Thus instead of a century-old, one-room schoolhouse on a barren site, this district has an up-to-date school plant with sufficient play space and grounds that are a genuine inspiration.

TRADE AND CIVIC CENTERS.

Rural village life is intimately connected with farm life. The village is the trade center and frequently the educational, religious and social center for farmers. The life of the village is almost wholly dependent on the surrounding farming community. Whatever makes the village more orderly, more harmonious, more beautiful, more efficient, is of vital interest to the farmer.

This emphasizes the importance of the village portal—the gateway from the country to the village. A neat, orderly, inviting entrance in the form of a wagon road, or trolley and railway station makes entrance and exit a pleasure, tempts the traveler to tarry and makes cooperation between village and country easy and pleasant. Streets that are parked, planted with trees and lined with business houses of dignified, though simple design, not only develop village pride but usually become the most effective trade centers.

Villages are finding that the central, orderly grouping of such public buildings as post office, town hall, school, and church as civic centers makes for convenience and efficient administration and meets the canons of good taste in civic design. Farmers, too, are recognizing the value of the central orderly grouping of rural public buildings, and in advanced communities the consolidated school with its garden or demonstration plot and playground, the church, the grange hall, the library or community house, and perhaps a community grove as a picnic ground and outdoor recreation center, are often all grouped in a central location.

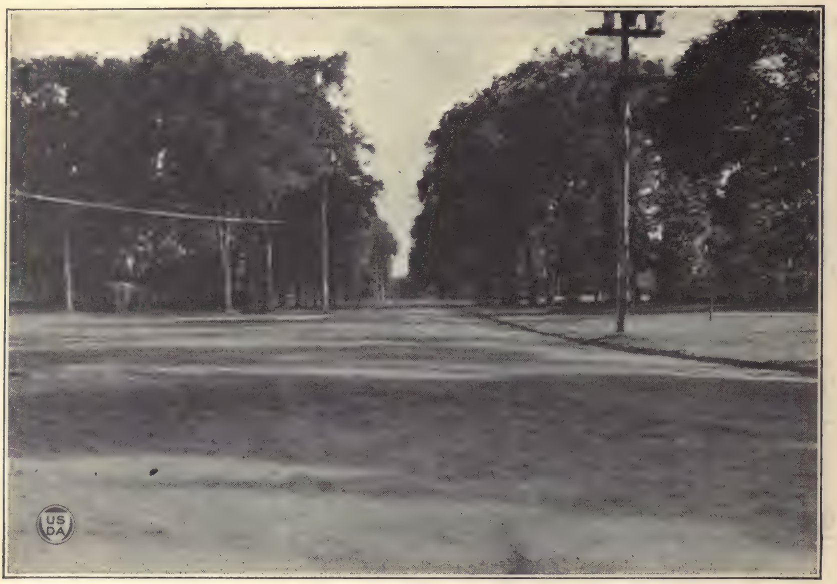


FIG. 11.—Not all "Main Streets" are bare and uninviting. Granby Street, Granby, Conn., is lined with attractive open-lawn residences.

RURAL CIVIC CENTER, GRANBY, CONN.

Granby is the usual New England agricultural town, made up of several villages with a common center. That part in which we are interested consists of one organized fire district, with a population of 280, and its center is Granby Street (Fig. 11). The citizens were always interested in the civic and esthetic development of the place. Running water, electric lights, and fire apparatus made for the convenience and protection of the people, while other features made for attractiveness.

Granby Street is a wide avenue lined with stately elms and with attractive homes separated from the street by spacious well-kept lawns. At the head of the street there used to be a gully which served as the village dumping place. Realizing the importance of an inviting gateway, an improvement association was formed and voluntary contributions were secured. The gully was filled in, shade trees and ornamental shrubs planted, paths and tennis courts laid out, and the place was dedicated as a village park. Later a Civil War monument of good design was erected at the entrance. This park is the scene of sports, band concerts, outdoor entertainments, and various public celebrations. (Fig. 12.)

Improvements were also made in the old village cemetery, where burials dated back to 1690. A cemetery association was formed and capitalized at $1,000, trees and shrubs were set out, drives and fences repaired, the grass mowed, and provisions made for the permanent upkeep of the place.

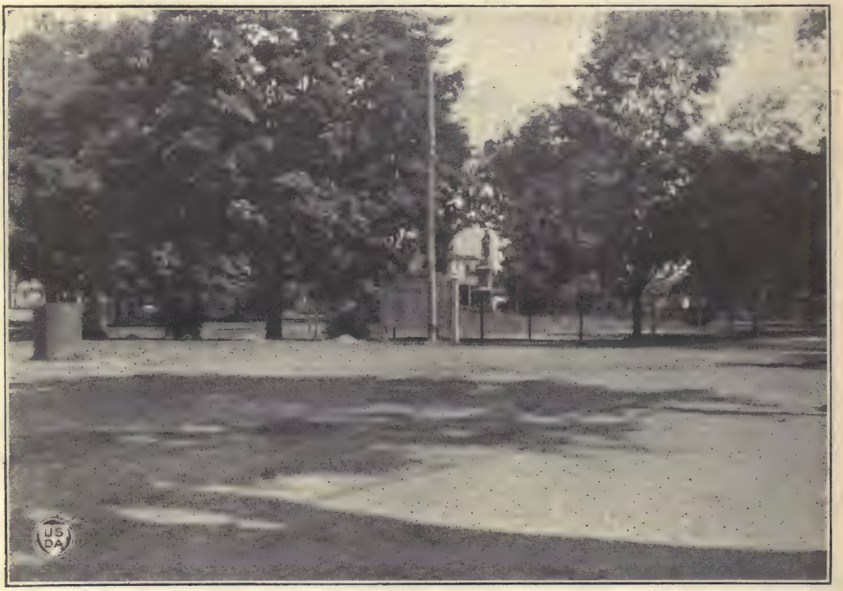


Fig. 12.—Village park showing the World War honor roll, the Civil War monument, tennis court, and band stand, Granby, Conn.

With such a background of civic interest we are prepared for a more striking instance of community effort. About five years ago two local residents, of old village stock, made known their decision to found a library in recognition of benefits received by themselves and their ancestors from the community.

Shorty afterwards the citizens found it advisable to change the local educational system to conform to modern principles of teaching, and thus a new school building became necessary. Finally the desirability of a special building where the social affairs of the village might be held, and the need of a public playground, had long been felt by the community.

Here was the opportunity, therefore, of making a reality of an idea long entertained by local leaders; that is, the establishment of a village community center, where all the common needs—social, religious, educational, and recreational—should find their satisfaction.

About this time the village church, which from early days had been the center of the religious and social life of Granby Street and the surrounding farming community, was destroyed by fire.

As the church was perhaps the strongest local organization and as most of the people of the community were either members or adherents, it was decided to make it the focus of the enterprise. Accordingly about 4 acres of land were purchased by the church, which in turn gave ground for the library, community building, and school.

It was planned to make the church a symbol of all that is beautiful. The result was a well-equipped and convenient structure of attractive architectural design without and an interior of exceptional beauty and dignity. It was erected at a cost of $20,000, raised through general voluntary contributions of the people of the village and farming community, a few special gifts, and a small loan.

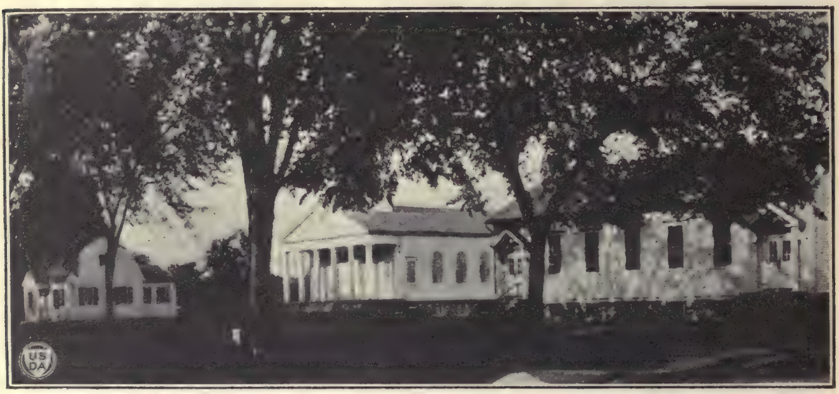


FIG. 13.—An attractive rural civic center, Granby, Conn. Left, library; center, church; right, community building. The school house is located at the rear of the library.

The library was erected at a cost of $10,000 and has one story, with the usual library features, club rooms in the basement, the whole being under the care of a librarian.

To the south of the church was placed the community building of somewhat plainer design It has an assembly hall with chairs for 200 people, which may be quickly removed, leaving the floor open for other purposes a well-appointed stage and dressing rooms, a spacious dining room, and well-equipped kitchen in the basement. It was built at a cost of $11,000 by the voluntary contributions from a large proportion of the community, and is the center of the social life of the village. (Fig. 13.)

Immediately to the rear of the library on a cross street is located the new schoolhouse, of harmonious design, so arranged structurally that new rooms may be added when the contemplated consolidation of districts is effected. It is the property of the town, which spent $5,000 in its erection.

In front of the schoolhouse, and at the rear of the other three buildings, is a 2½-acre lot which completes the five-sided community group. This is a general playground and recreational field for the use of the entire community.

Already this community center has demonstrated its worth, not alone in focusing the village life in a common center but in serving an as example to other rural communities. Since this group was completed the citizens, led by the civic club, have been instrumental in having a hospital established for the use of the community. (Fig. 14.)

The resources of this little village are probably no greater than those of many other villages of similar population. The principal industries are fruit raising and tobacco culture. There are no factories. But it is possessed of a citizenship of high civic, social, and religious ideals which realizes the worth of public order and convenience, is not unmindful of the value of the beautiful even in the country, takes the responsibilities of citizenship seriously, and, finally, is determined to maintain an enduring and satisfying country life.

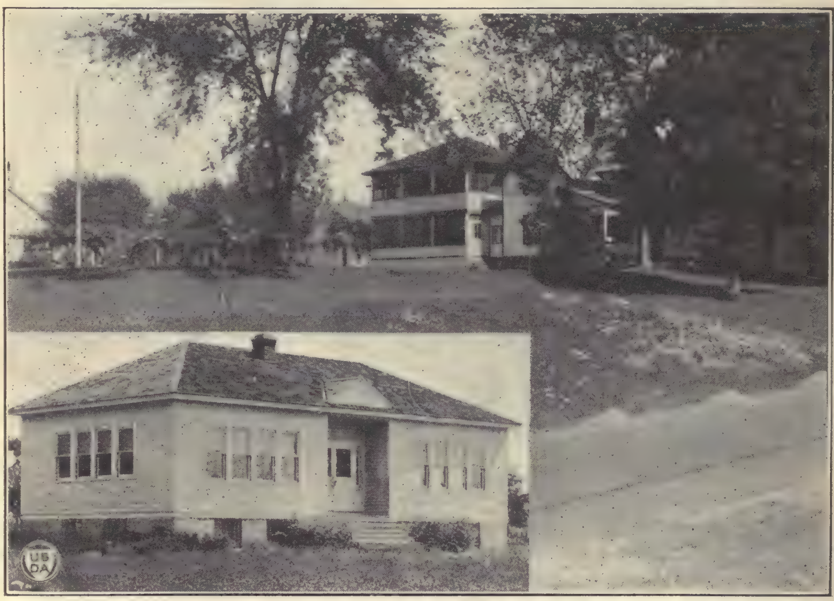


FIG. 14.—The community hospital across the street from the civic center, Granby, Conn. Insert shows school house located in rear of library, shown in Figure 13.

A VILLAGE REMADE, OJAI, CALIF.

Fifteen miles away and 1,200 feet above Ventura-by-the-Sea, in California, lies a beautiful valley in the midst of which was the old settlement of Nordhoff. Nordhoff was a typical early frontier settlement of the old régime with the usual plain one-story frame store buildings on one side of the street (Fig. 15), with old wooden sidewalks running along the unpaved street. On the opposite side were several dwelling houses of the usual style in such settlements. The drabness of the place was, of course, reflected in its social life.

To awaken this primitive village to its commonplace condition, one of its leading citizens purchased 10 acres on the opposite side of the street from the stores and constructed a park with tennis courts, a grandstand, and clubhouse. Along the side of the park facing the street a Spanish pergola was erected. The storekeepers were quick to see the contrast between their old worn-out buildings and the other side of the street with its beautiful Spanish arches and low walls inclosing a forest of live oaks. At that opportune moment the merchants were told if they would make certain changes on their side of the street, they, or the town, would be given the park together with a new post office building.

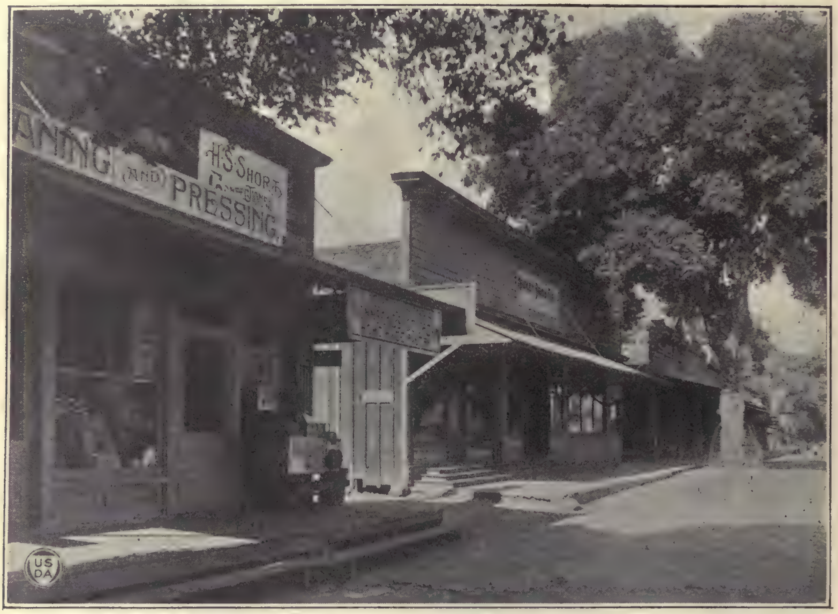


FIG. 15.—Main street before the village was remade, Ojai, Calif.

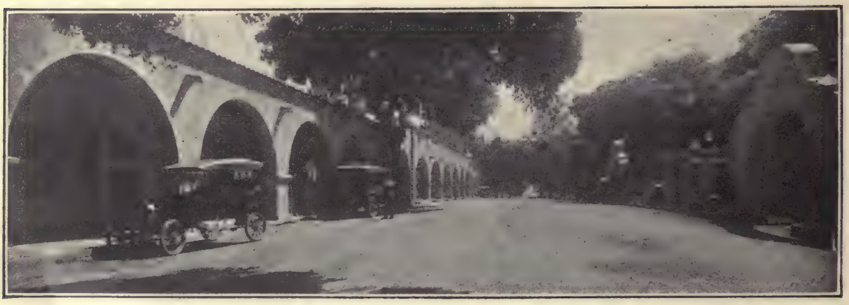


FIG. 16.—An inviting place to trade. Main Street improved. Park on right. Ojai, Calif.

The offer was accepted. Architectural plans were drawn up and executed, resulting in a uniform arched concrete front connecting all the stores. (Fig. 16.) At a cost of a few hundred dollars each storekeeper found himself the owner of a building not only of considerably greater value but also of much more attractive appearance. The town had lost a row of ugly buildings and gained a picturesque and harmonious street, park, and post office building, the latter being built in the form of a stately Spanish tower.

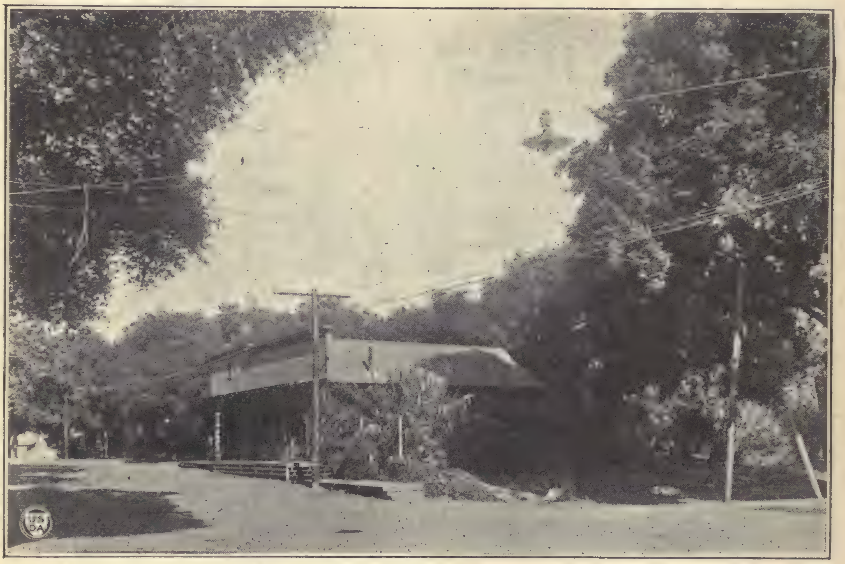


FIG. 17.—The old post office, Ojai, Calif.

The main part of this work was completed in 1917 at a cost of $30,000. Since that time the improvements of the place have gradually continued at a cost of $55,000. The merchants themselves maintained the work until the recent incorporation of the village under the name of Ojai, the name of the beautiful valley in which it is located. The whole project has demonstrated what may be accomplished through cooperation between merchants and citizens stimulated and led by a kindly spirit who believes in the practical value of the beautiful. (Figs. 17 and 18.)

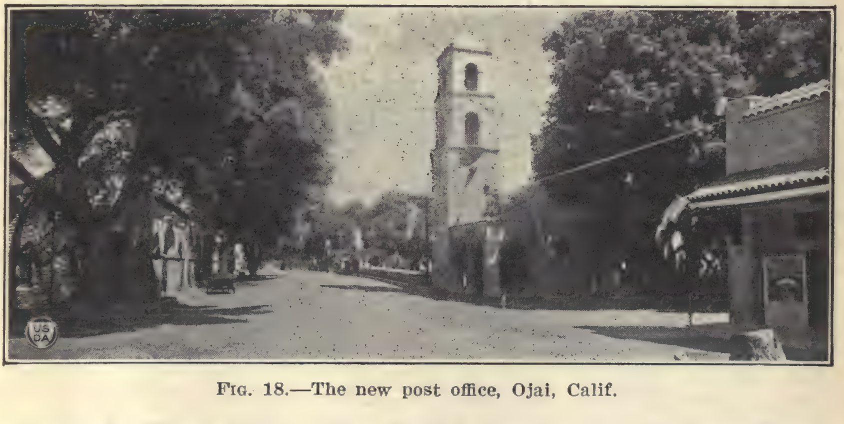


FIG. 18.—The new post office, Ojai, Calif.

The village now seems to be midway between the old and the new. It does not have the bustle and push and go of the so-called modern village, although it has all the conveniences of wholesome modern living. The atmosphere is that of a village dreaming in the sun.

When entering, one passes, first, a beautiful cloistered church, then a stately Spanish tower, rising above the new post office. Opposite is the new hotel, of Spanish design, and just beyond is the long Spanish arcade housing the business enterprises, including the new bank. Across the road lies the park with its Spanish arches and low walls inclosing the "forest," clubhouse, and tennis courts. The social and recreational life of the community are symbolized by restful parks, smooth boulevards, stately shade trees, pleasant riding paths, clubhouses, tennis courts, country places, and hotels and homes with wide verandas and beautiful vistas. The village as a whole, with its quiet beauty and good order, together with its wholesome social life, strikes a note of harmony, beauty, and restfulness.

An effort for improvement of this kind is sure to have an influence on other towns and people. A citizen writes:

> The result of the transformation of this village is one of which every merchant is very proud. Citizens and officials of other towns have come here to study the work. No doubt other villages and towns have been much inspired by the work here. A daily occurrence is for visitors to come and exclaim over its joys. It is very much appreciated. The common exclamation is: "Why don't we have more such places everywhere?"

A RURAL COMMUNITY CENTER, ORANGE TOWNSHIP, BLACKHAWK COUNTY, IOWA.

In the center of Orange Township is a row of well-kept homes and public buildings on both sides of a smooth paved road. The question sometimes asked is, "Where is the town?" meaning where is the general store, blacksmith shop, post office, grain elevator? As a matter of fact the only buildings, other than homes, are a consolidated school and a community church. It is not a town or village, only a community center. The well-kept homes with wide lawns in front and garden plots at the rear are largely those of retired farmers who, having spent their allotted time on the work of the farm, have decided to live their remaining years in the country where they have accomplished their life work and in so doing add their means and their experience to those of others in building a clean, healthful, and permanent rural life.

The homes are modern and possess most of the conveniences of city homes, while the gardens connect the interests of the people with their former occupation. The two public buildings (Figs. 19 and 20) are true rural institutions linked with the life of the country. In the school, representing the union of 10 one-room districts, an attempt is made to interest the children in the characteristic things of their daily lives and link the school with the farm and home. The boys have agricultural projects as a part of their school work and the products of their manual training are articles of actual use on the farm. The girls are taught to make their own clothing and to prepare meals. The church, although denominational, is the only one in the township and a very large proportion of the people are active members of the church and Sunday school.

Both the school and the church have exerted a particularly deep influence on the social life of the community. In the basement of the church is a well-equipped kitchen and a dining room, where community spreads and banquets are frequently held. On the main floor is a women's rest room furnished with rockers and couches

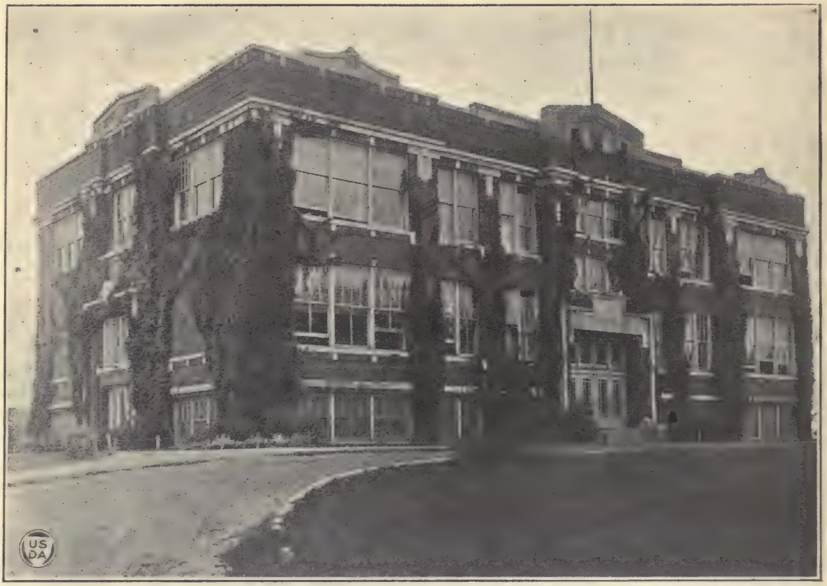


FIG. 19.—The township school, center of indoor activities, Orange Township, Blackhawk County, Iowa.

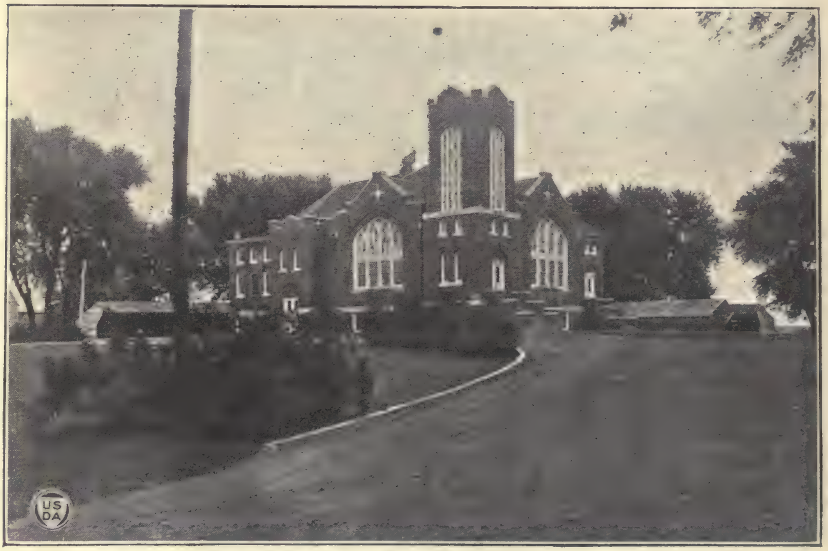


FIG. 20.—The church, center of religious and social activities, Orange Township, Blackhawk County, Iowa.

and beds for small children. The people have organized themselves into a community center with a community council in charge, which consists of the heads of eight prominent organizations. The council, at the beginning of the school year, arranges a program of social, educational, musical, and athletic events which are held weekly in the schoolhouse when possible.

In the pioneer days there had been many places where the people could go for picnics—lake shores, streams, and waterfalls—but these places were gradually commercialized and brought under the control of private interests. In the neighborhood there was a large maple grove, which was taken over at a nominal rental and placed under the control of the school as being the most permanent local organization. Voluntary contributions were used in this undertaking. At a community "working bee" the grove was cleaned, the ground leveled, trees trimmed, picnic benches made by the school manual training class and playground apparatus were installed and a bandstand was erected. (Fig. 21.) When the work was completed the women served a bountiful supper.

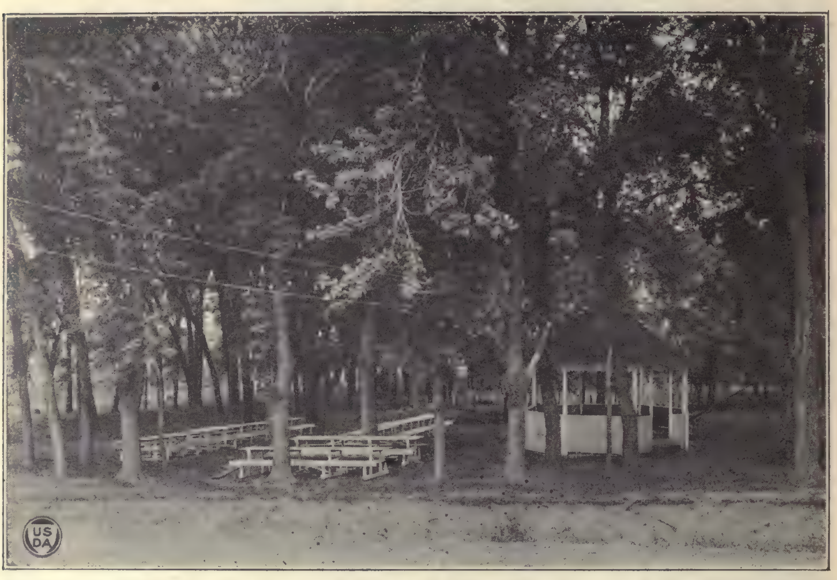


FIG. 21.—The picnic ground, center of outdoor community activities. Orange Township, Blackhawk County, Iowa.

At the beginning of summer the community council now prepares a program of outdoor amusements, held every two weeks in the grove, consisting of organized play and story hour for the children, baseball contests, band concerts, motion pictures with orchestral accompaniment, and community picnics. The community picnic has assumed an important place in the social life of the people and each year finds at least one such gathering for both old and young sponsored by such organizations as the grange, boys' and girls' club, cow-testing association, Holstein association, public school, Sunday school, church, or county women's Christian temperance union. These are augmented by the harvest home picnic, to which old residents come back; the newcomers' picnic, at which the newcomers to the township are guests; the Fourth of July picnic; and family picnics.

Thus in a purely rural community, similar to thousands of others in the United States, a group of people, practically all farmers, are endeavoring by the organization of the community on a social basis to make an attractive rural life so that farming people will be content to remain a permanent part of the agricultural community.

And with what result? A survey of this township made by an Iowa college showed that the number of young people in the township 20 years of age or older is 104, 54 young men and 50 young women. By far the majority in each case are now on the farm or stated that they expected to go back to the farm. Twenty-eight of the 50 young women are married; 21 of these, or 75 per cent, are married to farmers.

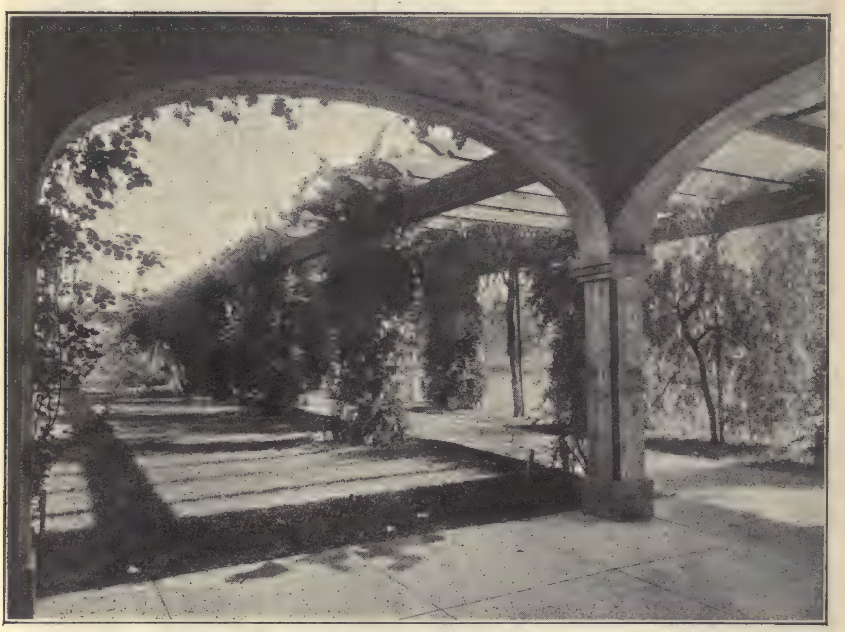


FIG. 22.—Sidewalk protection in a warm country. Chandler, Ariz.

The survey indicates that in the township the number of young persons remaining on farms is larger than the average of Iowa communities. It seems safe to assume that the attempt of the people to strengthen the community spirit on the moral, religious, and social side has been, in part at least, responsible for this.

IMPROVEMENT IN A RURAL COMMUNITY, CHANDLER, ARIZ.

The desirability, in a hot climate, of protecting persons and sidewalks from the direct rays of the sun resulted in the construction of a unique protecting screen in Chandler, Ariz., by one of its citizens. The wooden framework (Fig. 22), covered by vines, extends a distance of two blocks. No great amount of attention to the shelter has been needed after the original expense. As a sidewalk protection and town ornament it has received much favorable comment and has been copied in various other places in that section of the country.

Irrigation ditches passing through corporate limits often present difficulties in the general scheme of village improvement. Too often they are considered as necessary evils, much as the town dump was formerly regarded, and little attempt is made to incorporate them into the general plan of betterment.

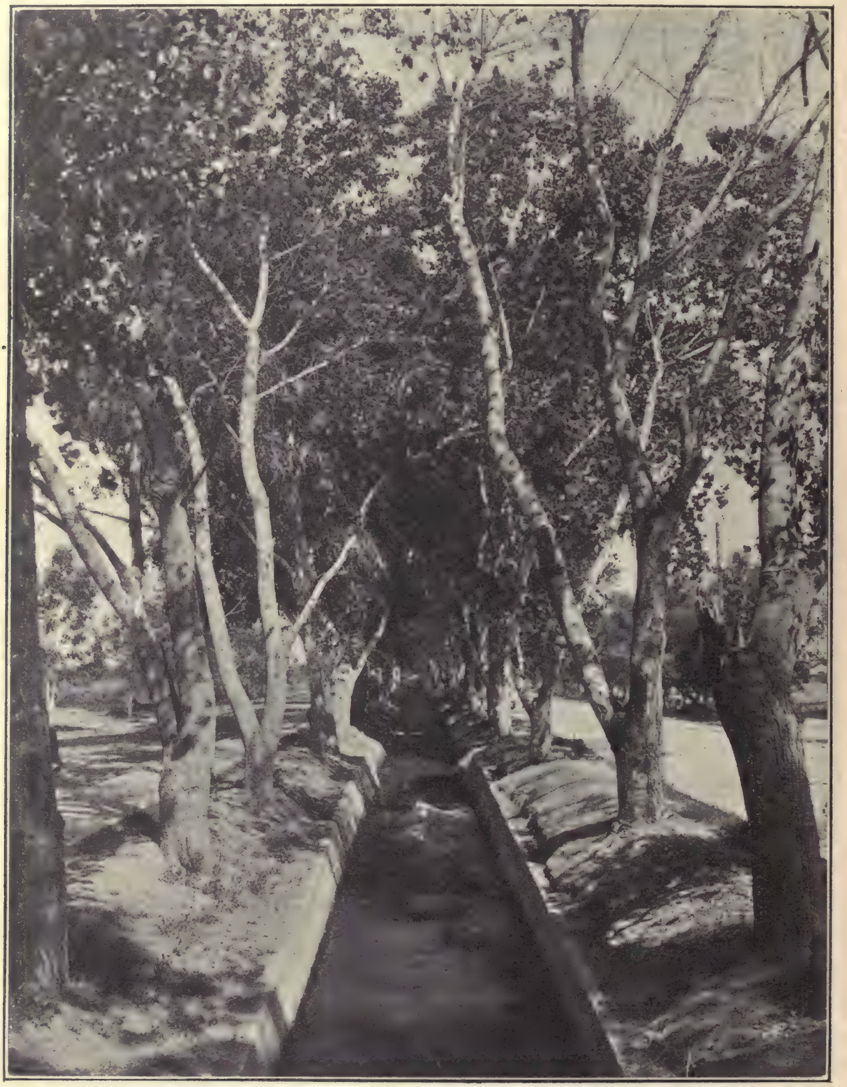


FIG. 23.—A well-treated irrigation ditch. Chandler, Ariz.

In Chandler the difficulty has been met in a novel way. Rows of trees were planted along the banks of both sides of the ditch and a concrete walk was constructed next to each row of trees, the whole making an attractive promenade along running water in an arid country. (Fig. 23.) This landscape effect is one of the main features of the town. The walks extend from the railway station down through the middle of one of the streets to the center of the town and out to the edge of town, a total distance of half a mile.

The founder of the village formulated the idea and financed the work in the belief that a new town should be built not only on practical lines but on principles underlying the ideas of cleanliness, order, and beauty.

An attractive approach to a farm home suggests cordial welcome and a home of worth and dignity. The owners of the driveway, shown in Figure 24, have succeeded, in an arid country, in constructing a driveway both inviting and useful, for the trees in this particular example are date palms, four years old, and at maturity are expected to return a considerable profit each year.

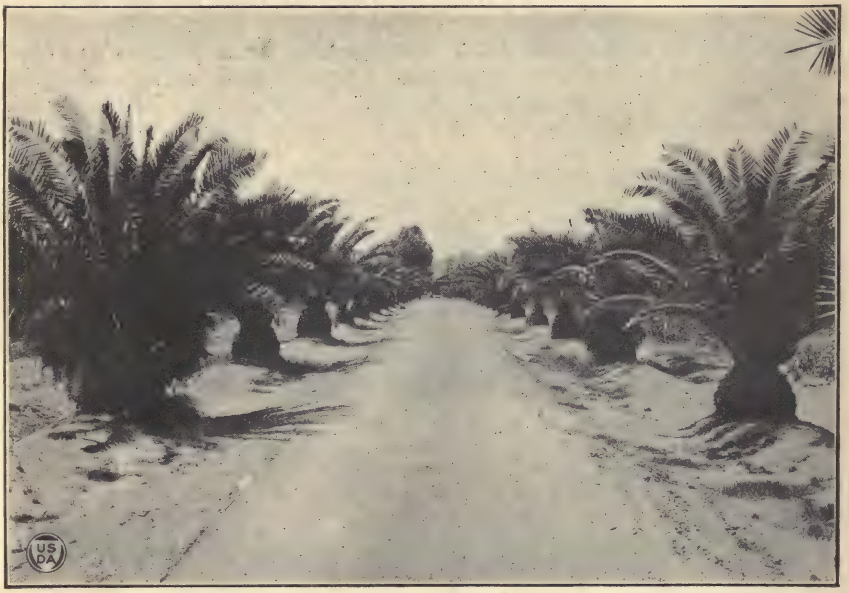


FIG. 24.—An inviting approach to a farm home. Chandler, Ariz.

It is not surprising that a number of other farmers in the vicinity have made use of similar ideas and have made their drives both attractive and profitable.

Every section of the country has local material, such as palm, maple, elm, catalpa, walnut, or eucalyptus, which might well be used for similar purposes.

A TOWN GATEWAY, LOCUST VALLEY, N. Y.

A number of railroad corporations believe that it is good practice, from the standpoint of their own interests, to make their stations and grounds an attractive town gateway, regardless of local assistance, and have established a general policy in that direction.

It often happens, however, that the best general and permanent results, from the viewpoint of the town, are obtained by community cooperation with the railroad. A town that meets the railroad halfway in the matter with local aid deserves to, and generally does, receive greater financial consideration from the railroad.

Formerly the station in the small village of Locust Valley, N. Y., was an 18 by 28-foot frame building, set in most commonplace surroundings on farm land which was also used for a pasture.

The coming of several new families seemed to quicken a community consciousness and a campaign was started for a better station and more attractive station grounds. An indirect result was the formation, as an aid to the work, of a neighborhood association which, incidentally, exists to this day, and has a remarkable list of civic achievements to its credit. In a few years a dignified and commodious station of durable material took the place of the small wooden structure.

Considerable additional land was secured as a station site and the whole was formally arranged and planted, and walks and driveways were built. Through cooperation between the railroad and citizens about $2,500 was raised and expended in this work. Since then more land has been acquired until now the grounds are 5 acres in area.

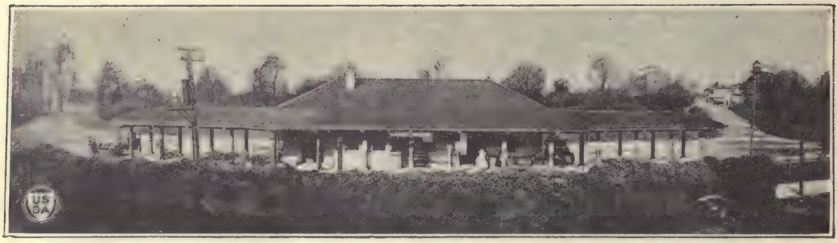


Fig. 25.—An attractive gateway to a rural village. The ground improvements at the rear are on the station grounds. Locust Valley, N. Y.

Across the track was a lumber and coal yard. The view from the station was screened by lilac bushes and a lattice fence covered with clematis vines. Later a group of members of the neighborhood association acquired the land on which the yard was situated in order that the land might be used for parking and other public purposes. (Fig. 25.)

The work is maintained through a cooperative agreement between the railroad company and the neighborhood association, the railroad agreeing to contribute $300 a year and the association the remainder, which has averaged about $400 a year. Laborers have been hired to keep the grounds in condition by oiling the roads, caring for the lawn, clearing up refuse, pruning the trees, and attending to plants and shrubs.

The agreement has been in effect for a number of years and has seemed to work satisfactorily. One of the chief benefits of the improvement of station grounds is the suggestive effect that it has on the improvement of the grounds of public buildings and private residences. A member of the station grounds committee of the neighborhood association writes:

The community spirit has spread and I think everyone is trying to keep home and grounds in good condition. Improvements for the public benefit are usually carried out without much opposition, which indicates that the neighborhood feeling is now deeply rooted.

CONCLUSION.

City planning is coming to occupy a permanent place in our civic life. Country planning should follow city planning, although there are at the present time good reasons for believing that the interests of our national life can best be conserved by major emphasis on the proper planning and development of our rural sections and the conservation of their resources. It is hoped that this publication of some actual accomplishments in the field of rural planning, from the social viewpoint, may aid, through the force of example, in bringing about this consummation.

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